HYDROLOGIC REVIEW OF BLM's FEDERAL RESERVED RIGHT CLAIMS FOR ARAVAIPA CANYON WILDERNESS AREA

In re Aravaipa Canyon Wilderness Area
(In re the General Adjudication of the Gila River System and Source)

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HYDROLOGIC REVIEW OF BLM's FEDERAL RESERVED RIGHT CLAIMS FOR ARAVAIPA CANYON WILDERNESS AREA

EXECUTIVE SUMMARY

This report presents a review by Plateau Resources LLC (Plateau) of the federal reserved right claims to Aravaipa Canyon Wilderness Area (ACWA), located in southeastern Arizona. The Bureau of Land Management (BLM), who administers the property, has claimed various flows in Aravaipa Creek, which runs through the canyon, including flood events, base flow, annual flow and unimpounded flood flow. BLM has also claimed water for 14 springs and 12 ponds within ACWA.

The ACWA claims are being adjudicated before a Special Master who initiated a contested case in the matter in August 2009. In April 2012, the Special Master set an evidentiary hearing to answer several questions regarding the claims, specifically, how much, if any, unappropriated water was available on the dates that Congress established ACWA and, if such water was available, what is the precise quantity required to meet the minimum need and satisfy the primary purpose of the reservation?

This report was prepared on behalf of Freeport McMoRan Corporation, a Litigant in the ACWA case. The purpose of the report is to assist the Special Master at the evidentiary hearing by focusing on the hydrologic basis for BLM's federal reserved right claims and determining whether those claims are consistent with historic and recent streamflow data. This report also evaluates whether unappropriated water was legally and physically available to meet BLM's claims. The ecological basis of BLM's claims was evaluated separately by SWCA Environmental Consultants (SWCA), which prepared its own report that addresses the minimum quantity of water needed to sustain the aquatic and riparian ecosystem of ACWA. The two reports are complimentary and supplement each other.

Plateau's recommendations regarding BLM's federal reserved right claims to Aravaipa Creek are summarized in **Table 12** of this report. The table includes Plateau's

recommended values for flood events, base flow, annual flow and unimpounded flood flow. For comparison, the table also lists BLM's ACWA claims and its existing state-based rights to Aravaipa Creek. The following conclusions are drawn from this table:

a) BLM consistently and substantially overestimates the magnitude of flood events in Aravaipa Creek and fails to consider changes in the magnitude of these events along the creek;
b) Unappropriated water is not legally available to meet BLM's base flow claims due to existing instream flow rights and, for extended periods, this water is not physically available either. Water rights require both legal and physical availability;
c) BLM also overestimates its annual flow claim on account of several factors including missing flow data from the period of record, use of average rather than median values, and its failure to evaluate spatial changes in flows along the creek; and
d) BLM's unimpounded flood flow claim, which it calculates as the difference between its base flow and annual flow claims, is affected by the errors noted above and, therefore, is overestimated as well.

With respect to BLM's spring and pond claims, Plateau determined that all but two of the springs and all of the ponds are associated with other water right filings and most of these have priorities that predate the reservation. This indicates that all or a portion of the water claimed for these springs and ponds may already be appropriated and not available to meet the ACWA federal reserved right claims. In addition, claimed discharge rates for the springs and capacities for the ponds are often inconsistent with the prior filings. In some cases the claimed amounts are higher than the filings and in other cases they are the same or lower. Moreover, based on comparison to other data sources, some claimed quantities do not appear accurate.

Results from Plateau's analysis of the spring and stockpond claims are summarized in **Tables 10** and **11**, respectively. Plateau recommends that BLM be required to explain the basis of its pond and spring claims and the effect that prior water right filings have on

these claims. It also recommends that the Arizona Department of Water Resources conduct field inspections to verify claimed locations, spring discharge rates and pond capacities.

Finally, although not a focus of this report, Plateau also evaluated if changes in Aravaipa Creek base flows have had an impact on ACWA visitation rates. It finds that there is no obvious relationship between decreases in base flow and the number of people that have visited ACWA. In fact, increased base flows have, at times, seemed to decrease the number of visitors, probably due to safety and/or access concerns

1. INTRODUCTION

1.1 Background

The Aravaipa Canyon Wilderness Area (ACWA) is located in southeastern Arizona, northeast of the town of Mammoth.[1] Congress established ACWA on August 28, 1984 and later expanded it on November 28, 1990. The Bureau of Land Management (BLM) administers the property and filed its first federal reserved right claims for ACWA in March 1991.[2] The claims were filed in a judicial proceeding to determine the extent and priority of water rights in the Gila River System (*In re General Adjudication of All Rights to Use Water in the Gila River System and Source*). BLM has since amended its federal reserved right claims to ACWA three times with the latest amendment filed by the United States Department of Justice (United States) in January 2012. A copy of the January 2012 amendment is provided in **Appendix A**.

The Special Master assigned to oversee adjudication of the ACWA claims initiated a contested case in the matter in August 2009 (*In re Aravaipa Canyon Wilderness Area*). In a November 2011 order he determined that the portion of ACWA designated by Congress in 1984 had the following purposes:

- Protection of the area;
- Preservation of its wilderness character;
- Gathering and dissemination of information regarding the area's use and enjoyments as wilderness;
- Preservation and protection of the complex of desert, riparian and aquatic ecosystems;
- Preservation and protection of the native plant, fish and wildlife communities dependent on the foregoing complex of ecosystems; and
- Protection and preservation of the area's scenic, geologic, and historic values.

The lands added to ACWA in 1990 were found to have the first three of these purposes.

[1] Aravaipa Canyon is drained by Aravaipa Creek. From its headwaters in Graham County, the creek flows approximately 60 miles, first to the northwest and then west, before joining the San Pedro River in Pinal County, south of Dudleyville. According to the Arizona Department of Water Resources (1991, p.447), Aravaipa Creek is the largest perennial tributary to the San Pedro River. Aravaipa Canyon begins about 10 miles upstream from the creek's confluence with the river.

[2] Statement of Claimant (SOC) No. 39-68704.

In April 2012, the Special Master set an evidentiary hearing to answer five questions regarding the federal reserved right claims for ACWA:

1. Did Congress intend to reserve all unappropriated waters with ACWA?
2. How much, if any, unappropriated water was available on August 28, 1984?
3. If unappropriated water was available on August 28, 1984, what is the precise quantity of unappropriated water required to fulfill the minimal need of, and satisfy, the primary purposes of the Arizona Wilderness Act of 1984?[3]
4. How much, if any, unappropriated water was available on November 28, 1990?
5. If unappropriated water was available on November 28, 1990, what is the precise quantity of unappropriated water required to fulfill the minimal need of, and satisfy, the primary purpose of the Arizona Desert Wilderness Act of 1990?

The evaluation presented in this report addresses Questions 2 through 5.

In its November 2012 initial disclosure statement for the case, the United States argues that "the facts will show that the entire amount of unappropriated water constituting the natural flow in the wilderness area is the amount of water necessary to preserve and protect the area's wilderness character; its complex of desert, riparian and aquatic ecosystems; the native plant, fish, and wildlife communities dependent on the foregoing complex of ecosystems; the area's scenic, geologic, and historical values; and its use and enjoyment as wilderness." The Special Master considers this argument in his November 2011 order and states that "(w)ithout evidence establishing the quantity of available water and water needed to fulfill the purposes of the wilderness area, the Special Master cannot answer this question." (p.18)

1.2 Purpose and Scope

Rich Burtell of Plateau Resources LLC (Plateau) prepared this report on behalf of Freeport-McMoRan Corporation (Freeport), a Litigant in the ACWA contested case. Mr. Burtell is an environmental scientist with 25 years of project and management experience. He is a Registered Geologist (AZ No. 33746) and principal and owner at

[3] From a hydrologic perspective, and for purposes of this report, "minimal need" is equivalent to an amount of water sufficient to satisfy the primary purpose of the reservation. These terms are used interchangeably herein.

Plateau with degrees in geology and hydrology. Areas of expertise include water rights and demand analyses and evaluation of ground and surface water resources. Before founding Plateau, Mr. Burtell worked at the Arizona Department of Water Resources (ADWR) for twelve years where he was manager of the Adjudications Section. As manager of that section, he was frequently involved in evaluating federal reserved right claims.

The purpose of the report is to assist the Special Master in answering four of the questions to be addressed at the evidentiary hearing (Questions 2 through 5). More specifically, this report evaluates the hydrological basis for BLM's January 2012 federal reserved right claims and whether those claims are consistent with historic and recent streamflow data. It does not evaluate the ecological basis of BLM's claims. That evaluation was conducted separately by SWCA Environmental Consultants (SWCA), which has prepared its own report for the case on behalf of Freeport. SWCA's report addresses the minimal quantity of water needed to sustain the aquatic and riparian ecosystem of ACWA and supplements Plateau's report.

This report also provides an initial analysis of the quantity of unappropriated water available to ACWA on August 28, 1984 and November 28, 1990. The Special Master assigned the analysis of unappropriated water, in part, to the Arizona Department of Water Resources (ADWR). In August 2012, he directed ADWR to summarize and evaluate all state law based water rights and claims held by the United States in ACWA and update the watershed file report (WFR) that ADWR included for ACWA in its 1991 Hydrographic Survey Report for the San Pedro River Watershed (1991 San Pedro HSR). That information as well as ADWR's summary and review of the federal claims are due in February 2014.

1.3 Report Organization

The remainder of this report is organized into five sections. Section 2 reviews BLM's federal reserved right claims to Aravaipa Creek and is divided into 3 subsections – Flood Events (**Section 2.1**), Base Flow (**Section 2.2**) and Annual and Unimpounded Flood

Flows (**Section 2.3**). **Sections 3** and **4** provide an analysis of BLM's federal reserved right claims to springs and stockponds in ACWA, respectively. Plateau's recommendations based on the above review and analysis are presented in **Section 5** followed by references in **Section 6**.

2. ARAVAIPA CREEK CLAIMS

In its January 2012 amended SOC, BLM claims an annual flow of 24,600 acre-feet (AF) in Aravaipa Creek for instream use within ACWA. The quantity is divided into a "total base flow" claim of 9,444 AF and "un-impounded flood flow" claim of 15,156 AF. BLM also claims instantaneous flood flows in Aravaipa Creek which it estimates in cubic feet per second (cfs) for specific return periods. This section of the report provides a hydrologic review of each component of BLM's claims to Aravaipa Creek – flood events (**Section 2.1**), base flow (**Section 2.2**), and annual and unimpounded flood flows (**Section 2.3**).[4]

The United States indicates in its November 2012 initial disclosure statement that the factual basis for BLM's ACWA claims includes "assessment of the hydrologic conditions that existed at and prior to the time of reservation; an analysis of the aquatic ecosystem including water necessary to support native fish habitat; analysis of the riparian ecosystem; and amounts of water necessary for recreational use and enjoyment of the wilderness." Experts for the United States filed four reports in the case, one for each of these areas. The report by Swanson (2013), which assesses the hydrologic conditions that existed at and prior to the reservation was the focus of Plateau's hydrologic review in this section.[5]

When reviewing BLM's federal reserved right claims to Aravaipa Creek, it is important to consider where the rights will be applied. This is because the amount of flow needed differs from one location to the next along the creek. The United States indicates that the place of use is "within the ACWA boundary." However, no compliance point is provided that specifies where on Aravaipa Creek the rights would be measured. The claims are based on a USGS gage located about 6 stream miles downgradient of the west boundary

[4] BLM determines its unimpounded flood flow claim by simply subtracting the total baseflow claim from the annual flow claim. Plateau, therefore, focused its review on the baseflow and annual flow claims.

[5] Plateau also reviewed, in part, the expert report by Moore (2013) which evaluated how streamflows in Aravaipa Creek can affect recreational values. In addition, it examined numerous documents disclosed in the contested case by Freeport, Salt River Project and the United States as well as information Freeport obtained through subpoena of the Arizona Game and Fish Department, The Nature Conservancy (TNC), and Dr. Peter Reinthal of the University of Arizona.

of ACWA.[6] This section of the report analyzes whether those gage data are complete and representative of streamflow conditions on the east and west boundaries of the reservation. Results from Plateau's analysis should assist the Special Master in determining the quantity of Aravaipa Creek flows that are needed to enter ACWA from its east boundary and leave on its west boundary to meet the minimal needs within the reservation.

2.1 Flood Events

BLM claims that the following instantaneous flood flows (in cfs) and return periods (in years) must be maintained along Aravaipa Creek to preserve the ACWA ecosystem:

- 4,540 cfs (2 year)
- 15,600 cfs (10 year)
- 26,300 cfs (25 year)
- 37,000 cfs (50 year)
- 50,700 cfs (100 year).

According to Swanson (2013, p.5), these claims are based on "the statistical characteristics of the historic flood regime over the period of record (from 1932) up to 1984." The period of record refers to data collected at U.S. Geological Survey (USGS) streamflow gage 09473000, located 6.3 stream miles below the west boundary of ACWA (**Figure 1**). As Swanson (2013, p.6) further describes:

> *Twenty-eight complete years of record are available in this period and include the following years: 1932-1940, 1942, 1967-1984. The beginning of the analysis was set at 1932 to coincide with the first available* (calendar) *year of complete and reliable record. The end of the analysis was set at 1984 which coincides with the establishment of the* (ACWA).

[6] Plateau approximated the stream miles presented in this report through digital planimetry of current 1:24,000 USGS topographic maps.

2.1.1 Return Period Analysis

Swanson (2013) does not specify how BLM derived its claims for Aravaipa Creek flood events. Plateau reviewed those claims and summarizes its results in **Table 1.** The review indicates that BLM has overestimated the instantaneous flood flows that occur in ACWA.

Using a slightly longer period of record and a standard Log Pearson Type III analysis, USGS (1998, p.364) calculated flood flow frequencies for gage 09473000 that are consistently lower than BLM, with differences increasing with longer return periods. For example, at a 2-year return period, the USGS calculated a flood flow of 3,980 cfs compared with 4,540 cfs claimed by BLM. The difference was greater at the 100-year return period with the USGS calculating 26,900 cfs and the BLM claiming 50,700 cfs.

Plateau independently evaluated the flood events using a standard guideline for flood flow analyses (Bulletin 17B) and the USGS (2007) computer program PeakFQWin. Output from Plateau's PeakFQWin simulations are provided in **Appendix B**. Utilizing a similar period of record as BLM, Plateau calculates instantaneous flood flows that are slightly higher than were determined by USGS (1998) but still appreciably less than BLM's claims. When Plateau utilized the full period of record available from USGS gage 09473000 (1919 through 2012), it again finds that its flood flow estimates were substantially less than BLM's claims.[7] For example, using the full period of record, Plateau determines that the 100-year flood is 32,060 cfs compared to BLM's claim of 50,700 cfs.

As a final check on BLM's flood flow claims, Plateau reviewed the analysis of a large flood event that passed through Aravaipa Canyon on August 1, 2006. USGS (2008a, p.41) estimated that the flood had a peak flow of about 28,000 cfs and characterized the flow event as "slightly less than the 100-year flood." This is in line with Plateau's calculations based on both the partial and full period of record for the gage.

[7] The reliability of flood flow estimates generally increases with a longer period of record (Linsley and others, 1982, p.358).

The flood flow data presented here show that BLM has substantially overestimated the instantaneous flood events it claims for ACWA and these claims should be reduced accordingly if these flows are to be monitored at the USGS gage.

2.1.2 Drainage area effect

The USGS gage BLM uses to quantify its federal reserved right claims is located 15.8 stream miles downgradient of the east boundary of ACWA and 6.3 stream miles downgradient of the west boundary (**Figure 1**). This raises the question whether streamflow data collected outside of ACWA are representative of flow conditions within the reservation.

To evaluate the effect that gage location has on BLM's flood flow claims, Plateau first determined the drainage area of Aravaipa Creek at the east and west boundaries of ACWA and then compared these to the drainage area at USGS gage 09473000. As expected, the drainage area increases across the reservation, from 411 square miles (mi^2) at the east boundary to 503 mi^2 at the west boundary and 537 mi^2 at the USGS gage.[8]

Plateau then evaluated how this increase in drainage area could affect flood flows by running the USGS (2012) National Streamflow Statistics Program (NSSP). The computer program calculates streamflow statistics at ungaged sites using data from nearby gages. Output from Plateau's NSSP simulations are provided in **Appendix C** and summarized in **Table 2**.

Using the full period of record available from USGS gage 09473000, NSSP estimates that flood flows along Aravaipa Creek at the east boundary of ACWA are about 24% lower than those measured at the USGS gage. At the west ACWA boundary, flood flows along Aravaipa Creek are estimated to be about 10% lower than the USGS gage.

[8] The USGS (1998, p.362) drainage area for gage 09473000 compares well with Plateau's calculation of 542 mi^2. In December 2008, USGS moved its gage about 0.7 stream miles downgradient to a fish barrier constructed across Aravaipa Creek. USGS (2013) reports the same drainage area at the new gage site as it did for the old. Plateau also calculated the drainage area at the new site and found that it had increased by about 1 mi^2 to 543 mi^2.

It should be noted that the standard error of these flood flow estimates ranges from 30 to 43% at the east boundary and from 53 to 67% at the west boundary. As such, the NSSP estimates are not exact. Nonetheless, the estimates are reasonable and confirm the increase in flood flows that is commonly associated with an increase in drainage area. A more rigorous analysis using a rainfall-runoff model would be needed to refine these estimates. BLM did not provide such a model and apparently assumed that the substantial change in drainage area across ACWA has no effect on its instantaneous flood flow claims.

2.2 Base Flow

BLM's federal reserved right claims to Aravaipa Creek also include monthly base flows (in cfs) and volumes (in AF):

- January – 16 cfs (982 AF)
- February – 18 cfs (998 AF)
- March – 18 cfs (1,105 AF)
- April – 13 cfs (772 AF)
- May – 10 cfs (614 AF)
- June – 6 cfs (356 AF)
- July – 10 cfs (614 AF)
- August – 14 cfs (859 AF)
- September – 12 cfs (713 AF)
- October – 11 cfs (675 AF)
- November – 12 cfs (713 AF)
- December – 17 cfs (1,043 AF).

According to Swanson (2013, p.4), these base flows represent "the median of all daily means…for the indicated month in the period of record." As described in **Section 2.1.1**, the period of record used by BLM covers 1932 through 1984 and includes streamflow data collected at USGS gage 09473000. BLM's total base flow claim of 9,444 AF was calculated by adding each of the monthly claims.

2.2.1 Comparison to instream flow rights

The ACWA evidentiary hearing will address two questions related to the quantity of unappropriated water available at the time of reservation. Aravaipa Creek is located in the portion of ACWA that was reserved on August 24, 1984. In its 1991 San Pedro HSR, ADWR identifies numerous water uses within and upstream of ACWA that predate establishment of the reservation. Among these uses are state-based instream flow rights that BLM holds for Aravaipa Creek within Aravaipa Canyon.[9] The rights were certificated with a priority date of June 1, 1981 and a place of use that begins near the east boundary of ACWA. This point is where the rights are also to be measured and where BLM located its East End Wilderness streamflow gage (**Figure 1**).

Table 3 compares the quantity of BLM's state-based instream flow rights to its federal reserved right claims for base flows in Aravaipa Creek. Monthly flow rates are included in the table along with the basis of the rights and claims. The table also lists four instream flow rights held by The Nature Conservancy (TNC) for Aravaipa Creek. These rights are located immediately upstream and downstream of ACWA but postdate establishment of the 1984 reservation.

On a monthly basis, the quantity of BLM's instream flow rights to Aravaipa Creek generally exceeds its federal reserved right base flow claims. Since the priority of the instream flow rights predates the reservation, unappropriated base flows are not available for ACWA during these months. During three months (April, September and November), the instream flow rights are slightly lower than the baseflow claims. Based on the difference between BLM's claims and its instream flow rights, the quantity of unappropriated base flow could range from 1 to 3 cfs for these months. However, this assumes that no other upstream water users with earlier priority dates perfect their claims, which is unlikely due to the history of irrigation in the area.

Also, when BLM originally applied for instream flow rights on Aravaipa Creek, it requested a continuous base flow of 15 cfs including 10 cfs for wildlife and fisheries and

[9] Certificate of Water Right No. 33-87114.

5 cfs for ecosystem maintenance and aesthetic recreation values. When ADWR later permitted the rights, BLM modified its instream flow claims and requested monthly flow rates ranging from 10 to 25 cfs. It stated that these average daily flows each month represented "the minimal amounts of flow needed to maintain and preserve the character of water-dependent values in the (ACWA)." (BLM, 1988a, pp.9-10) In 1996, ADWR certificated the requested permit amounts.

The discussion above indicates that BLM's instream flow rights for Aravaipa Creek were perfected largely for the same purpose as its federal reserved right base flow claims and BLM has not indicated that its instream flow rights are in any way insufficient. So, since the instream flow rights predate the reservation, no unappropriated flow is legally available from Aravaipa Creek for its base flow claims. This conclusion is consistent with BLM's own assessment of its water rights in the 1988 Wilderness Management Plan for AWCA (p.7):

> *An implied federal reserve water right was created when (ACWA) was designated. Established water rights existing under state law prior to creation of the wilderness area would not be affected by a federal reserve water right claim. If unappropriated water is available, the amount claimed by BLM would be limited to the amount required to satisfy wilderness purposes.*

2.2.2 Physical availability

In addition to legal availability is the question whether Aravaipa Creek streamflows are physically available to meet BLM's base flow claims. As illustrated by Swanson (2013, pp.8-12), the base flow claims were derived from flow duration curves that BLM developed for each month by combining all of the daily mean streamflows recorded that month over the period of record and then ranking the flows from largest to smallest. The middle of this ranked dataset, where the flow rate is equaled or exceeded 50% of the time, is its median value and equal to BLM's monthly base flow claim.

What Swanson's flow duration curves fail to capture is how baseflows in Aravaipa Creek have actually varied from month to month and year to year. **Table 4** lists the median flow measured at USGS gage 0947300 during each month from May 1931 through September 2013.[10] To show how these flows compare to BLM's base flow claims, the data fields are color coded. Warmer colors are used to show the months when actual median flows were less than BLM's claim and cooler colors show the months when these flows exceeded the claims. For example, values shaded red indicate that the median streamflow measured at the gage that month was more than 50% below BLM's base flow claim. Conversely, values shaded dark blue indicate that the median streamflow was more than 50% above the claim that month.

Review of **Table 4** shows that relatively long intervals have occurred during the full period of record when median flows in Aravaipa Creek were substantially less than BLM's base flow claims. Take for the example the 10-year period from 1968 through 1977. Over that period, median monthly flows in February ranged from 9.9 to 21 cfs and were from 25 to 50% below BLM's claim of 18 cfs in 7 out of 10 years. Beginning in 1978 and continuing through 2000, median monthly flows in Aravaipa Creek were typically well above BLM's claims, indicating a wet cycle. Then, beginning in 2001, a dry cycle began (and continues today) with median monthly flows in Aravaipa Creek typically well below the claims.

Plateau understands that wet and dry cycles are a common and natural climatic feature that can have profound effects on streamflows in the Southwest. Over extended periods, the quantity of base flow in Aravaipa Creek has been substantially below BLM's claims and, as discussed in **Section 2.3.2**, the recent declines in flow do not appear to be related to increased human demands. That suggests that similar periods of low base flow have occurred in the past and will likely occur again in the future.

[10] **Table 4** also lists miscellaneous streamflow measurements at the gage site when the gage was inoperable. These values do not necessarily represent the median streamflow for the month, but they do provide an indication of flow conditions during periods of missing record.

Since a minimal need standard applies in quantifying federal reserved water right claims, the Special Master should reduce BLM's base flow claims to reflect the lower flows that have been frequently measured in Aravaipa Creek. Otherwise, the rights will often be greater than the quantity of water physically available in the stream. This issue of physically available supply is independent of the issue of legal availability (e.g., the limitation of water availability on the date of reservation). For instance, as explained in **Section 2.2.1**, BLM's certificated instream flow rights for Aravaipa Creek predate the reservation and for most months exceed the federal reserved right base flow claims. This indicates that little or no unappropriated water is legally available.

2.2.3 Spatial variability

BLM's federal reserved right claims to Aravaipa Creek are based on streamflow data collected at USGS gage 09473000. As mentioned above, the gage is located 15.8 stream miles below the east ACWA border and 6.3 miles stream miles below its west border (**Figure 1**). This section of Plateau's review describes how base flows vary along Aravaipa Creek and affect BLM's claims.

The first records that Plateau found of changes in base flow along Aravaipa Creek were collected by USGS in April 1951. Starting several miles upstream of ACWA and ending a half mile downstream of the USGS gage, the following instantaneous discharge measurements were taken along Aravaipa Creek on April 3rd and 4th:

- 0.84 cfs – about 3.5 miles northwest of Klondyke;
- 10.8 cfs – near the east boundary of ACWA, 30 feet below Turkey Creek;
- 12.5 cfs – 75 feet below Parsons Canyon;
- 12.5 cfs – 100 feet below Horse Camp Canyon;
- 11.9 cfs – near the west boundary of ACWA on April 3rd;
- 13.9 cfs – near the west boundary of ACWA on April 4th;
- 13.3 cfs – at Lewis Ranch, about 2.2 miles below the west ACWA boundary;
- 11.7 cfs – at Aravaipa Farm, about 1.7 miles above the USGS gage; and
- 8.74 cfs – about 0.5 miles below the gage. (USGS 1977)

Others including Ellison (1980, pp.64-65), ADWR (1991, pp.451 and 453) and Fuller (2000, pp.3-6 to 3-9 and 5-2) also reported changes in base flow along Aravaipa Creek. Their discharge measurements were taken in 1979, 1990 and 1999, respectively, at points within and adjacent to ACWA. All describe increases in base flow from east to west across ACWA except during the early summer when flow rates were found to decline downstream. Increased flows were attributed to tributaries along the canyon that added surface and ground water to Aravaipa Creek. Evapotranspiration (ET) and irrigation diversions explained the summer declines.

The most systematic monitoring of base flows within ACWA has been made by BLM and TNC in support of their instream flow claims. Beginning in 1979 and continuing to present, instantaneous discharge measurements have been taken on more or less a monthly basis at the East End and West End Wilderness gage sites (**Figure 1)**.[11,12] Plateau compiled these base flow data and compared them to the mean daily flow recorded on the same days at USGS gage 09473000. Results from the comparisons are presented in **Tables 5** and **6**.

Table 5 shows the typical change in base flow that occurs from the east ACWA boundary to the USGS gage by month. Changes were calculated by first subtracting the East End instantaneous discharge measurements from the USGS mean daily flows. The median of these differences was then calculated for each month. Positive median values are listed in green and indicate that the base flows that month typically increased from the east boundary to the USGS gage. Negative values are listed in red and indicate that base flows that month were typically lower downstream.

[11] BLM established continuous streamflow gages at the East End and West End sites in summer 1980 and reported data from these gages through December 1982 and May 1988, respectively. ADWR (1995) notes that "(d)ue to numerous floods and the subsequent damage to the gages these streamflow monitor efforts were abandoned. Instead of maintaining and repairing gage stations, the BLM and (TNC) teamed efforts around 1989 to collect bi-monthly instantaneous streamflow data." According to Fuller (2000, p.3-1) records from the gages were "oriented at flows from between 0 and 100 cfs (0.0 and 2.8 m^3/sec), with greater accuracy in the 10 to 40 cfs (0.3 to 1.1 m^3/sec) range." Due to the relatively short period of record and accuracy concerns, Plateau does not further evaluate these data and relies on the instantaneous discharge measurements for its base flow analysis.

[12] Since 1985, TNC has also collected instantaneous discharge measurements at its Old School House site, located along Aravaipa Creek about 4 miles above the east boundary of ACWA.

Plateau finds that during the winter and early spring (December through April), base flows at USGS gage 09473000 are typically from 1 to 6 cfs higher than measured at the east boundary of ACWA. As described above, inflow from tributaries in Aravaipa Canyon explain these downgradient increases. Conversely, during late spring and through the fall (May through November), base flows at the gage are typically from 1 to 4 cfs lower than at the east boundary. Evapotranspiration and irrigation diversions can explain these decreases. One exception is August when runoff from monsoonal rains apparently offsets the ET and diversion losses and typically result in a 1 cfs increase in downstream base flow.

Table 5 also lists the change in base flow from the east ACWA boundary to the USGS gage as a percentage. Percentages were calculated by dividing the change in flow from upstream to downstream by the upstream flow and taking the median for each month. During the winter and early spring, base flows typically increase from 3% to 28% downgradient and, during the late spring through the fall, typically decrease from 4% to 24%. These results demonstrate that use of USGS gage data to represent base flows at the east ACWA boundary will typically overestimate those flows during part of the year and underestimate them during the other part.

Plateau performed a similar analysis using instantaneous discharge measurements from the west ACWA boundary and found that base flows in Aravaipa Creek typically decline from that point downstream to the USGS gage. As listed in **Table 6**, the declines typically range from 1 to 5 cfs. For two months (January and August) there was typically no change in base flow along this reach and for one month (December) there was typically a 3 cfs increase. These results indicate that, for most of the year, tributaries contribute little if any baseflow below ACWA. These results also suggest that, in addition to ET and diversion losses, base flows are being lost below Aravaipa Canyon due to infiltration. The alluvial channel of Aravaipa Creek becomes broader and likely deeper in this area.

Use of USGS gage data to represent base flows at the west boundary of ACWA will, therefore, typically underestimate base flows during most months. On the other hand, use of these data to represent baseflows at the east ACWA boundary will typically overestimate these flows during half of the year and underestimate them during the other half. These distinctions are not important in the final analysis of BLM's base flow claims since Plateau has already determined that no unappropriated water is available to meet the claims.

2.2.4 Effect on recreational values

In his report on the recreational value of streamflows in ACWA, Moore (2013, p.16), an expert for the United States, concludes that "(d)irect recreational enjoyment of Aravaipa Canyon Wilderness (hiking and swimming in Aravaipa Creek; enjoying its sound and visual beauty; and perceiving the wilderness area as natural and untrammeled) has been documented to diminish as streamflows in Aravaipa Creek decline below and rise above 23 CFS." Plateau does not attempt to verify this statement but it does assess whether changes in base flow in Aravaipa Creek have had any noticeable impact on the number of people that visit ACWA. **Figures 2a** through **2c** show the results of that assessment.

In **Figure 2a**, Plateau plots the annual number of visitors to ACWA from 1974 through 2012 and overlays the annual median daily streamflow measured in Aravaipa Creek at USGS Gage 09473000. The gage is located several miles below the east and west ACWA border and, depending on the season, base flows at the gage may be somewhat higher or lower than at the borders. For reference, the figure also highlights where flows equal 23 cfs, the rate at which Moore (2013, p.15) indicates that direct recreational values peak.

Recent decreases in streamflow along Aravaipa Creek do not appear to have caused any reduction in ACWA visitation rates. In fact, **Figure 2a** shows that the number of visitors has generally increased since 2000 even though flows over this period are substantially lower than before due to drought. There is, however, a relationship between higher base flows and visitation. In years when median daily flows were substantially above 23 cfs,

the annual number of visitors was generally lower, likely due to access and/or safety concerns caused by the higher flows.

Figures 2b and **2c** present similar information but compare the annual number of visitors to median daily streamflows measured during the spring (March through May) and fall (October and November). According to BLM and others (2010, p.37), ACWA visitation is greatest during those months. As observed in **Figure 2a**, there seems to be no relationship between reductions in base flow below 23 cfs and the annual number of visitors. Likewise, when base flows have been substantially above this rate, declines in visitation are observed.

Declines in Aravaipa Creek base flows have had no apparent effect on the number of people that visit ACWA. Conversely, elevated base flows may, at times, decrease visitation.

2.3 Annual and Unimpounded Flood Flows

In addition to flood events and base flows, BLM's claims to Aravaipa Creek include unimpounded flood flows. BLM quantifies these flood flows by subtracting its annual base flow claim of 9,444 AF from the average annual flow measured at USGS gage 09473000. As stated by Swanson (2013, p.6):

> *"identifying a specific quantified flood regime (e.g. magnitude, duration, frequency) suitable for maintaining the wilderness ecosystem is not practical for the water right claim. As a surrogate for a specific flood regime, a mean annual volume of 24,600 ac-ft is claimed to protect the annual wilderness character of the hydrograph. This 24,600 ac-ft includes the 9,444 ac-ft identified as monthly base flows. The additional 15,156 ac-ft is claimed as random and unmitigated flood flows distributed throughout the year."*

This portion of the report focuses on BLM's annual flow claims for Aravaipa Creek, analyzing how these claims are affected by the period of record for the USGS gage and

the location of the gage relative to ACWA. The effect that BLM's annual flow claim has on its unimpounded flood flow claim is addressed toward the end.

2.3.1 Period of record extension

Swanson (2013, p.4) describes the period of record used for BLM's annual flow claim as follows:

> *…the first approach for quantifying the water right is to characterize the natural, long-term flow regime. This characterization is best represented by an annual hydrograph that illustrate the typical flow fluctuations over a 12-month calendar year. However, the annual hydrograph should not be characterized by the conditions of flow from a single year. The flow regime is created by conditions established over a number of years. Because the reservation was established in 1984, conditions prior to this date should be evaluated to characterize the flow regime. Stream flow claims for Aravaipa Creek are based on complete years of record between 1932 and 1984 at the USGS stream gage (# 09473000) located on Aravaipa Creek near Mammoth, AZ. Twenty-eight complete years of record are available in this period and include the following years: 1932-1940, 1942, 1967-1984. The beginning of the analysis was set at 1932 to coincide with the first available year of complete and reliable record. The end of the analysis was set at 1984 which coincides with establishment of the Aravaipa Canyon Wilderness Area.* (emphasis added)

Annual streamflow records are not available from USGS gage 09473000 during 1941 and from 1943 through 1966 (25 years). To evaluate what effect this missing record has on BLM's annual flow claims, Plateau extended the gage's period of record by correlating its flows to a nearby stream gage with similar basin characteristics but a longer record. USGS gage 09468500 was selected and is located about 30 miles northeast of Aravaipa Creek on the San Carlos River near Peridot. The watershed above the San Carlos River gage has a drainage area of 1,026 mi^2, a mean annual precipitation of 17.2 inches and diversions for irrigation of about 600 acres. By comparison, the watershed above the

USGS gage on Aravaipa Creek has a drainage area of about 537 mi^2, a mean annual precipitation of 16.2 inches, and irrigation of "several hundred acres" above the station. USGS (1998, pp.324-325 and 362-363)

Ordinary least-squares (OLS) regression was used to correlate annual streamflows at the two gages over their common period of record.[13] The resulting linear regression model is presented in **Appendix D** and was used to estimate flows in Aravaipa Creek for those years when data were only available from the San Carlos River. **Figure 3** shows the original and extended period of record for USGS gage 09473000. Using the original period of record through calendar year 1984, BLM and Plateau both calculate a mean (average) annual flow in Aravaipa Creek of 24,600 AF. However, by extending the period of record through regression with the San Carlos River gage, Plateau calculates an average annual flow in Aravaipa Creek through 1984 of 21,100 AF, a decrease of 3,500 AF or about 14% below BLM's claim. This indicates that BLM overestimated its annual flow claim for Aravaipa Creek by ignoring the missing period of record at USGS gage 09473000.[14]

Years of unusually high streamflow can skew average annual values and Aravaipa Creek is no exception. As seen in **Figure 3**, annual flows at USGS gage 09473000 during 1983 totaled approximately 120,000 AF, well above prior and subsequent years. In such cases, the *median* annual value is more representative of typical flow conditions in a given year. The median annual flow in Aravaipa Creek using BLM's original period of record is 18,900 AF, substantially less than its claimed average annual flow of 24,600 AF. Using Plateau's extended period of record, the median annual flow reduces further to 16,400 AF. Neither the United States nor its experts explain why BLM uses average rather than median annual flows for its ACWA claims. Plateau reserves the right to evaluate additional evidence on the difference between annual and median flows, including any

[13] According to USGS (1998, p.324), flow in the San Carlos River above gage 09468500 was regulated by Talkalai Reservoir beginning in June 1979. For that reason, Plateau only compares annual streamflows from this gage to gage 09473000 through calendar year 1978.

[14] For comparison, Plateau also extended the period of record for Aravaipa Creek using another commonly utilized regression model, the maintenance of variance extension type 1 (MOVE.1) technique of Hirsch (1982). The difference in annual streamflows calculated by the two models is less than 1% and not considered significant.

expert reports submitted by another party, and to revise its opinions on this topic accordingly.

Clearly if BLM's federal reserved right claims to Aravaipa Creek are to be based on average annual flow, it is imperative to use an extended period of record so that individual years like 1983 do not have a disproportional effect on the final value. Plateau's opinion is that the lower average annual flow it estimated for Aravaipa Creek by extending the period of record is due to drought. Increased human demands may have also affected flows in the creek during that period. These topics are addressed below.

2.3.2 Droughts and Human Demands

USGS (1991, pp.183 and 185) identifies three regional droughts that affected Arizona and the Aravaipa Creek watershed during the 20th century. The drought periods are listed below with their recurrence interval:

- 1932 to1936 (10-20 year event);
- 1942 to1964 (greater than 100 year event); and
- 1973 to 1977 (15-35 year event).

The period of record that BLM uses to estimate average annual flows in Aravaipa Creek includes the 1930s and 1970s droughts but misses all but one year of the 1942 to 1964 drought. This supports the conclusion that BLM's claims likely overestimate the long-term average annual flow in the creek.

Plateau took a longer look at the potential effect that droughts have had on the watershed by plotting the Palmer Drought Severity Index (PDSI) for southeastern Arizona from 1800 through 2006.[15] Cook and others (2008) reconstructed these PDSI values using tree rings. Their data are plotted in **Figure 4** and show that a series of drought and wet cycles have occurred in the region over the last 200 years. To aid in viewing these cycles, a five-

[15] According to McPhee and others (2004, pp.4 and 7), the PDSI "compares temperature, precipitation and other factors to index medium-to-long term variations in soil moisture…(It) uses a subjective scale for classifying drought; values between -2.0 to -2.9 are considered to represent moderate drought, -3.0 to -3.9 for severe drought, and below -4.0 for extreme drought." By comparing PDSI values to precipitation records, McPhee and others found that PDSI values for Arizona are "a faithful recorde(r) of drought on a time scale of approximately one year."

year running average PDSI value is also plotted which smoothes out year-to-year variability.

The 1942 to 1964 drought period is clearly visible in **Figure 4** and was a major event, as earlier noted by USGS (1991). The 1930s and 1970s droughts are less visible and do not appear that unusual. The figure also shows that long-term drought cycles are not uncommon in the region, having occurred in the 19th century and now at the beginning of the 21st century. Plateau's opinion is that BLM's failure to consider these natural drought cycles have affected their calculation of the average annual flow in Aravaipa Creek.

Plateau also considered how human demands may have affected flows in the watershed. Historically, the largest water use in the Aravaipa Creek watershed has been for irrigation. **Table 7** compiles historic changes in irrigated acreage along Aravaipa Creek from the 1920s through 2010. Irrigated areas upstream of USGS gage 09473000 are listed separately for the reaches above and below ACWA. Irrigation in the area appears to have peaked in the mid-20th century, with about 800 to 900 acres under cultivation, and has since declined. This indicates that the period of greatest human water demand probably coincided with the major drought from 1942 to 1962. Flows in Aravaipa Creek have, therefore, been even lower than Plateau estimates in **Section 2.3.1**.[16]

Mining was another water demand in the watershed. Hadley (1991, pp.99, 106, 121, 129, and 298-299) notes that a mill and concentrator were operated at Klondyke near Aravaipa Creek from 1925 through 1931 **(Figure 1)**. The facilities were rebuilt in 1948 and operations continued until 1957 when mining activities in the region ceased. The quantity of water used for ore processing is unknown, but the location of the mill and concentrator near Aravaipa Creek suggests that some impact to flows in Aravaipa Creek was possible.

[16] ADWR (1991, p.C-73) calculates a water duty of 5.23 feet per acre for crops grown in the Aravaipa Creek watershed based on a consumptive use requirement of 2.58 feet per acre and an irrigation efficiency of 49%. Irrigation of 800 to 900 acres could, therefore, have required from 4,200 to 4,700 AFA. Some of this water was supplied directly by diversions from Aravaipa Creek with the remainder pumped from wells. Some portion of this water supply probably went back into Aravaipa Creek as irrigation return flows.

Like irrigation, these impacts would have largely coincided with the drought from 1942-1964 and reduced annual flows in Aravaipa Creek.[17]

Annual flows in Aravaipa Creek have historically been reduced by both drought cycles and human demands. Neither factor was explicitly evaluated by BLM although both appear to have peaked during the period when USGS gage 09473000 was inoperable. It is Plateau's opinion that BLM's annual flow claim, which is based on data from the gage, overestimates the long-term annual flow in Aravaipa Creek.

2.3.3 Drainage area effect

Plateau next analyzes how average annual flows in Aravaipa Creek vary spatially. As with flood events, annual flows typically increase with drainage area. To evaluate what effect this has on BLM's federal reserved right claims, Plateau estimated the average annual flow in Aravaipa Creek at the east and west boundaries of ACWA. Estimates were made using the drainage-area ratio method which computes flow for an ungaged site located near a gaged site (index station) based on the ratio of their drainage areas and flow data from the index station. In this case, the index station is USGS gage 09473000 which BLM used to calculate its annual flow claim.

According to USGS (2008b, p.6), the drainage-area ratio method is "often used where the ungaged site is on the same stream, upstream or downstream, of the gaged site and the drainage-area ratio of the two sites is between 0.5 and 1.5." Relative to the USGS gage, the drainage-area ratio for the east and west boundaries of ACWA is 0.77 and 0.94, respectively, which is within the range.

USGS (1990, pp.21-23) applies this methodology to evaluate streamflow characteristics within the San Carlos Indian Reservation, which borders the Aravaipa Creek watershed

[17] Impacts from municipal/domestic water demands would have been minor, both then and now. Hadley (1991, pp.229-300) estimates that the local population peaked between 1920 and 1930 with more than 400 people on the east side of ACWA and 300 on the west side. This population declined during the Depression and declined further after mines in the region closed in 1957. Less than 200 people have lived in the area since 1980 (ADWR, 2009, p.101). Even at its peak, the local population would have likely consumed less than 100 AFA.

to the north, as well as on the adjacent Fort Apache Indian Reservation. The following equation is used in their study:

$$Q_u = Q_g * [A_u/A_g]^X$$

where

Q_u = mean annual discharge at ungaged site (in cfs);

Q_g = mean annual discharge at index site (in cfs);

A_u = drainage area at ungaged site (in mi^2);

A_u = drainage area at gaged site (in mi^2); and

X = exponent.

The exponent, X, was determined based on the relationship between mean annual discharge and drainage area for index gages in regions with similar basin characteristics. For their study, USGS (1990) identifies two regions based on mean basin elevation. For gages with mean basin elevations less than 7,500 feet, values for X range from 0.97 to 1.04. Since the mean basin elevation for USGS 0947300 is approximately 4,530 feet (USGS, 1998, p.363), Plateau used this range of exponent values and the above equation for its estimates of annual flows.

Table 8 summarizes the results from Plateau's analysis of the effect of drainage area on average annual streamflows in Aravaipa Creek. Based on the drainage-area ratio method and using BLM's original period of record, the average annual discharge at the east boundary of ACWA is estimated to range from 18,800 to 19,100 AFA, about 23% lower than BLM's annual flow claim. The estimated average annual flow at the west ACWA boundary ranges from about 23,100 to 23,200 AFA which is about 6% lower than BLM's claim.

The differences are greater if the extended period of record for the USGS gage is used instead, which is more accurate in Plateau's opinion. In that case and as shown in **Table 8**, the average annual discharge in Aravaipa Creek at the east ACWA boundary is estimated to total about 16,100 to 16,400 AFA or about 34% lower than BLM's claim. At the west ACWA boundary, the average annual discharge is estimated to total about 19,800 to 19,900 AFA or about 19% lower than BLM's claims.

2.3.4 Effect on unimpounded flood flow claims

On both sides of the reservation, average annual flows in Aravaipa Creek are lower than at the downstream USGS gage where BLM calculated its claim. As a result, BLM overestimates its unimpounded flood flow claim since that was calculated by subtracting BLM's base flow claim from its average annual flow claim. BLM claims 15,156 AFA of unimpounded flood flows in Aravaipa Creek which it calculated by subtracting its base flow claims of 9,444 AFA from its annual flow claims of 24,600 AFA.

Plateau recalculated BLM's unimpounded flood flow claims by applying the extended period of record for the USGS gage and accounting for the difference in annual flow between the gage and the east and west ACWA boundaries. It also substituted BLM's state-based instream flow rights in place of its base flow claims since the former, which total 10,840 AFA, exceed the latter and have an earlier priority date. The instream flow rights are already appropriated and, in Plateau's opinion, unavailable to meet BLM's federal reserved right claims.

Based on the above corrections, Plateau estimates that BLM's claims to unimpounded flood flows in Aravaipa Creek are at most from 5,300 to 5,600 AFA at the east ACWA boundary and from 9,000 to 9,100 AFA at the west boundary. This is a substantial decrease from the 15,156 AFA that BLM calculated using its base flow claims and the original period at the USGS gage. **Table 9** shows how these calculations were made.

3.0 SPRING CLAIMS

BLM's federal reserved right claims for ACWA include 14 springs, four with a priority date of August 28, 1984 and 10 with a priority date of November 28, 1990. Legal descriptions for the springs and a map showing their general location are provided in the January 2012 amended claims filed by the United States (**Appendix A**). Claimed amounts range from 0.12 AFA for Stone Cabin Spring to 80 AFA for Hanging Spring, with a total spring claim of 182.94 AFA.[18]

Plateau completed a preliminary review of the spring claims based in part on a query of ADWR's current surface water filings database. Plateau also reviewed the WFR for ACWA from ADWR's 1991 San Pedro HSR as well as various spring discharge data sources. This review is considered preliminary because it did not include field inspection of the spring sites to verify their location and discharge.

In response to Freeport's request for data supporting the federal reserved right claims, the United States disclosed recent discharge data for two of the springs, Natural Boundary and Purgatory. No other information relevant to the claimed springs was disclosed by the United States or its experts. As directed by the Special Master, ADWR's review of the ACWA claims is due February 2014. If new information regarding the springs is contained in that report or otherwise becomes available, Plateau reserves the right to revise or supplement the opinions presented here.

Table 10 summarizes the results from Plateau's analysis of the ACWA spring claims. The analysis focuses on prior water right filings associated with the springs, spring locations, and claimed amounts. Each topic is discussed below.

3.1 Prior Filings

Plateau found prior water right filings associated with all but two of the ACWA springs (Hanging and Janette). The prior filings are listed in **Table 10** under the "Data Source"

[18] BLM also claims "(a)ny other naturally occurring waters (e.g., seasonal Cienegas, small riverside oxbow lakes, undiscovered seeps, springs, ponds, etc.) with (sic) the ACWA" but did not locate or quantify these.

column and include state-based certificates of water right (CWR), statements of claim, statements of claimant and applications to appropriate surface water. BLM is the current holder of these rights and claims.

Most of the filings claim priority dates that are earlier than establishment of the reservation in 1984 and its expansion in 1990. As such, the prior filings indicate that all or a portion of the water from these springs is already appropriated and unavailable to meet BLM's federal reserved right claims for ACWA. In fact, three of the springs (Goat, Purgatory, and Saltuna) have separate federal reserved right claims filed pursuant to Public Water Reserve No. 107 (PWR 107) with 1926 priority dates. ADWR's analysis of the ACWA claims, which are due February 2014, should further address this issue and include recommended water right attributes for springs as well as the ponds reviewed in **Section 4**.

3.2 Location

Plateau evaluated the location of the ACWA springs by comparing their claimed locations to the various prior filings. The only difference noted is for Natural Boundary Spring. The federal reserved right claim specifies its location is in the southwest quarter of the southwest quarter (SW¼, SW¼) of the section, whereas a prior water right filing (36-104905) indicates its location is in the SE¼, SW¼. Field inspection would be necessary to verify the location of this and the other ACWA springs.

3.3 Amount

BLM's amended claims for AWCA state that "the amount of water claimed for springs and seeps is the measured flow and corresponding volume per annum." **Table 10** lists the claimed amount for each spring and, for comparison, the amounts listed in prior water right filings. The table also indicates under the "Type" column whether these amounts represent a flow rate or quantity of use. While BLM's federal reserved right claims are all provided as flow rates, the prior filings are a mix of flow rates and quantities of use.

Plateau does not find a consistent relationship between BLM's claimed amounts for the springs and the prior filings. In some cases, the claimed amount is higher than the prior filings and, in other cases, it is the same or lower. Take Goat Spring for example. BLM claims a federal reserved right for the spring of 1.61 AFA. A prior statement of claim (36-61123) lists the quantity of use at 0.13 AFA and its PWR 107 claim (39-14492) indicates a quantity of use of 0.096 AFA with a flow rate of 1.6 AFA. Another statement of claimant (39-2643) filed earlier by Salazar lists the quantity of use at 0.33 AFA.

Another example is Lower Stone Spring. BLM claims a federal reserved right of 0.17 AFA for this spring which matches the quantities of use in a prior statement of claim (36-100198) and statement of claimant (39-6876). However, BLM also holds a Certificate of Water Right (CWR 85308) for this spring with a quantity of use of 0.84 AFA. The practical consequence of these examples is that, depending on the spring, there may or may not be unappropriated water available to meet BLM's more recent claims.

Plateau also compared BLM's federal reserved right claims to discharge measurements. As shown in **Table 10**, claimed amounts are typically equal to or less than the discharge measurements when the latter were available Consider Saltuna Spring, which BLM claims a federal reserved right of 58 AFA. Discharge measurements made during April 1987, November 2002 and December 2012 indicate flow rates at the spring have ranged from 5 to 36.4 gallons per minute (gpm) or 8 to 58 AFA assuming a constant flow rate all year. Discharge at McRae spring, on the other hand, was measured in November 1999 at 10 gpm (16 AFA) but its federal reserved right claim is only 0.13 AFA. Finally, Janette Spring has a reserved right claim of 8.1 AFA but the only discharge measurement Plateau can find for it was 4 gpm or 6.4 AFA in April 1991.

For most of the ACWA springs, Plateau only identified one discharge measurement that equaled or exceeded BLM's claim. This raises the question whether the claimed amounts are representative (i.e., would more discharge measurements during other seasons and/or other years be higher or lower?). And Plateau cannot locate discharge data for four of the springs (Buggar, Lower Stone, Lupie, and Stone Cabin). The four springs all have

claimed amounts that match the quantities of use listed in one or more prior filings. As indicated above, the United States did not provide relevant data for these springs in response to Freeport's discovery request.

Based on the above discussion, further analysis of BLM's spring claims is warranted. Specifically, BLM should explain the basis for each of its claims, including the amount, and the effect that prior filings have on the availability of unappropriated water.

4.0 POND CLAIMS

This section presents Plateau's analysis of 12 stock tanks and one reservoir claimed by BLM in ACWA. All have a November 28, 1990 priority date except for three ponds (Adalfo Tank and Mesa Tanks #1 and #3) with an August 28, 1984 priority. Legal descriptions for the ponds and a map showing their general location are provided in the January 2012 amended claims filed by the United States (**Appendix A**). Claimed pond capacities range from 0.03 AF for Mescal Tank to 3.25 AF for Daggar Draw Tank with a total pond claim of 16.09 AF.

Similar to BLM's spring claims, Plateau completed a preliminary review of the ACWA ponds based in part on a query of ADWR's current surface water filings database. Plateau also reviewed the WFR for ACWA from ADWR's 1991 San Pedro HSR as well as recent (August 2010) aerial photographs of the reservation. This review is considered preliminary because it did not include field inspection of the pond sites to verify their location and current capacity. Plateau reserves the right to revise or supplement the opinions presented here if new information regarding the ponds becomes available. ADWR's report on the ACWA federal reserved right claims is due February 2014 and may contain such information. In response to Freeport's request for data in support of BLM's pond claims, neither the United States nor its experts disclosed any relevant data.

Table 11 summarizes the results from Plateau's analysis of the ponds. The analysis focused on prior water right filings associated with the ponds, their location, and claimed capacities. Each topic is discussed below.

4.1 Prior Filings

Plateau found prior water right filings associated with each of the ACWA pond claims. The prior filings are listed in **Table 11** under the "Data Source" column and include state-based certificates of water right, stockpond claims, and statements of claimant. BLM is the current holder of most of these rights and claims, however, some were filed by lessees and do not appear to have been assigned to BLM.

All of the prior filings claim priority dates that are earlier than establishment of the reservation in 1984 and its expansion in 1990. As such, the filings indicate that all or a portion of the capacity of these ponds may already be appropriated and unavailable to meet BLM's federal reserved right claims for ACWA.

4.2 Location

Plateau evaluated the location of the ACWA ponds by comparing BLM's claimed locations to the prior filings. The only difference noted is for Mescal Tank. The federal reserved right claim specifies its location is in the NW¼, SW¼ of the section, whereas a prior water right filing (38-88245) indicates its location is in the NE¼, SW¼.

Plateau also evaluated the location of the claimed ponds through analysis of August 2010 photography. Unfortunately, Mescal Tank was not conclusively identified on the image so field inspection would be necessary to verify its location. Cave Pasture Tank was also not clearly visible but its claimed location matches two prior filing so field inspection is probably not needed in this case.

All remaining ponds are visible on the imagery and all but one of these matches BLM's claimed locations and the locations listed in prior filings. The one exception is Daggar Draw Tank. The federal reserved right claim and two prior filings (CWR 3940 and 38-88527) each list its location in the NE¼, NW¼ of the section while the imagery shows it in the NW¼, NE¼. BLM and/or ADWR should resolve this and the other locational discrepancies noted here.

4.3 Capacity

BLM's amended claims for AWCA state that "the amount of water claimed for ponds and small lakes is the maximum capacity." **Table 11** lists the claimed capacity of each pond and, for comparison, the capacities listed in prior water right filings.

Plateau does not find a consistent relationship between BLM's claimed pond capacities and the prior filings. In some cases, the claimed capacity is higher than the prior filings

and, in other cases, it is the same or lower. Take Brown's Tank which BLM claims a federal reserved right of 2.2 AF. Two prior filings for this pond both list its capacity at 0.5 AF including a Certificate of Water Right (CWR 3473) held by Salazar and a BLM stockpond claim (38-88425).

Another example is Tank Canyon Reservoir. BLM claims a federal reserved right of 0.27 AF for this pond. However, a Certificate of Water Right (CWR 85308) for the pond held by Sanford lists the capacity at 2 AF and BLM's stockpond claim (38-88405) lists a capacity of 1.0 AF. These examples show that, depending on the pond, there may or may not be unappropriated water available to meet BLM's federal reserved right claim.

As a further check on the claimed capacity of the ACWA ponds, Plateau estimated their surface area from the August 2010 aerial photography. Results are listed under the "Notes" column in **Table 11**. Some claimed capacities seem reasonable when compared to the pond's surface area but others less so. The following equation from ADWR (2008b, p.C-6) was used by Plateau to make the comparisons:

$$SC = SA^* H * 0.4$$

where

SC = stockpond capacity in acre-feet;

SA = surface area in acres;

H = embankment/berm height in feet; and

0.4 = pond shape factor.

Consider Mesa Tank #1 which BLM claims has a capacity of 1.4 AF. Recent aerial photography indicates that its surface area is about 0.5 acres. Using the above equation, its embankment/berm height would need to be about 7 feet high which is not unreasonable. On the other hand, BLM claims the capacity of Brown's and Houston Tanks at 2.2 AF and 2.38 AF, respectively. Recent imagery indicates that the surface area of each tank is about 0.1 acres. Using the above equation, their embankment/berm heights would need to be over 50 feet high.

The capacity data presented above indicate that further analysis of BLM's ponds claims is needed. As with the ACWA springs, BLM should explain the basis for each of its pond claims, including the capacity, and the effect that prior filings have on the availability of unappropriated water. Field inspection by ADWR is also warranted to verify the current condition and capacity of these ponds.

5.0 CONCLUSIONS AND RECOMMENDATIONS

In this section, Plateau presents its conclusions and recommendations concerning BLM's federal reserved right claims to ACWA. These findings are based on the hydrologic review described in previous sections and hopefully will assist the Special Master in answering questions at the ACWA evidentiary hearing. Namely, how much, if any, unappropriated water was available on the dates of reservation and, if such water was available, what is the precise quantity required to meet the minimal need and satisfy the primary purposes of the reservation?

This report, prepared on behalf of Freeport, focuses on whether BLM's ACWA claims are consistent with historic and recent hydrologic data. BLM is claiming streamflows in Aravaipa Creek and water at springs and ponds located across the reservation. SWCA evaluated the ecological basis of these claims and has prepared a separate report for Freeport on that topic. The two reports are complimentary and supplement each other.

5.1 Aravaipa Creek

Table 12 presents Plateau's recommended federal reserved rights to ACWA for Aravaipa Creek based on its hydrologic review of BLM's claims. Included are recommended values for flood events, base flow, annual flow and unimpounded flood flow. For comparison, the table also lists BLM's claims and existing state-based rights to Aravaipa Creek. In summary, Plateau concludes in Table 12 that:

a) BLM consistently and substantially overestimates the magnitude of flood events in Aravaipa Creek and fails to consider changes in the magnitude of these events along the creek;

b) Unappropriated water is not legally available to meet BLM's base flow claims due to existing instream flow rights and, for extended periods, this water is not physically available either. Water rights require both legal and physical availability;

c) BLM also overestimates its annual flow claim on account of several factors including missing flow data in the period of record, use of average rather than

median values, and its failure to evaluate spatial changes in flows along the creek; and

d) BLM's unimpounded flood flow claim, which it calculates as the difference between its base flow and annual flow claims, is affected by the errors noted above and, therefore, is overestimated as well.

5.1.1 Flood Events

BLM claims that instantaneous flood flows at specific return periods must be maintained along Aravaipa Creek to protect the ACWA ecosystem. It reportedly bases these claims on statistical analysis of streamflow records from USGS gage 09473000, located about 6 miles downgradient of the west boundary of ACWA and about 16 miles downgradient of its east boundary (**Figure 1**). Plateau reviews the flood events claimed by BLM in **Section 2.1.1** and finds, using both similar and longer periods of record from the USGS gage, that BLM consistently overestimates the flood magnitudes.

Furthermore, BLM indicates that its claims to Aravaipa Creek, including flood events, apply within the ACWA boundary. However, no compliance point is provided that specifies where its rights would be measured. In **Section 2.1.2**, Plateau evaluates the effect that the location of the USGS gage has on BLM's claims and finds that flood flows on the east ACWA boundary would be substantially (about 24%) lower than those measured at the USGS gage. The difference would be smaller (about 10% lower) at the west ACWA boundary.

Table 12 lists Plateau's recommended flood events along Aravaipa Creek for ACWA. Regardless of where the Special Master determines that these events should be measured, BLM's claims consistently and substantially overestimate the flood magnitudes.

5.1.2 Base flow

BLM claims monthly and annual base flows in Aravaipa Creek based on 28 complete years of record at the USGS gage. In June 1981, prior to establishment of ACWA, BLM filed for instream flow rights to Aravaipa Creek. The state-based rights were certificated

and are listed in **Table 12** alongside BLM's base flows for ACWA. As shown in the table, BLM's instream flow rights exceed its base flow claims on an annual basis (10,840 AFA vs. 9,444 AFA) as well as on a monthly basis for all but three months (April, September and November).

Since the priority of BLM's instream flow rights predates the reservation, it is Plateau's opinion that these flows are already appropriated and not legally available to meet BLM's federal reserved right claims to base flow. Moreover, BLM perfected its instream flow rights for largely the same purpose as its federal reserved right base flow claims – to maintain base flows in Aravaipa Creek for ecological purposes within ACWA – and makes no demonstration that its rights are insufficient for those purposes. As discussed in **Section 2.2.1**, Plateau recommends that BLM not be granted either a monthly or an annual quantity of baseflow for ACWA.

In addition to the issue of legal availability, there is the question of physical availability. Plateau finds, as described in **Section 2.2.2** and illustrated in **Table 4**, that base flows in Aravaipa Creek can remain substantially below BLM's claims for long periods, not just a year or two. These periods of low base flow appear unrelated to increased human demands and more likely were (and are) caused by extended drought. Droughts are a common and natural feature of the climate that can have profound effects on streamflows in the Southwest. Since a minimal need standard applies in quantifying federal reserved right claims, the Special Master should reduce BLM's base flow claims to reflect the lower flows that are physically available and frequently measured in Aravaipa Creek. Otherwise, any base flow rights granted to ACWA will often be greater than the quantity of water physically available and exceed the minimal needs of the reservation.

Also not addressed by BLM is how variations in base flow *along* Aravaipa Creek could affect its claims. As indicated above, BLM's federal reserved right claims to Aravaipa Creek, including base flow, are based on streamflow data collected at USGS gage 09473000, located about 6 miles downgradient of the west ACWA boundary and about 16 miles downgradient of its east boundary. Plateau finds, as summarized in **Tables 5** and

6, that baseflows generally increase from east to west along Aravaipa Creek except during the summer months. Increases are explained by inflow from tributaries along Aravaipa Creek and decreases are explained by ET and irrigation diversions.

Plateau concludes in **Section 2.2.3** that use of USGS gage data to represent base flows at the east ACWA boundary will typically overestimate these flows during half of the year and underestimate them during the other half. At the west ACWA boundary, the gage data will typically underestimate baseflow during most months. These distinctions are not important in the final analysis of BLM's base flow claims since Plateau already determined that no unappropriated water is available to meet those claims.

Finally, Plateau evaluates in **Section 2.3.4** how base flows in Aravaipa Creek compare to the number of people who annually visit ACWA. An expert for the United States concluded that "recreational enjoyment" of ACWA is related to the quantity of streamflow in the creek. Plateau assesses whether changes in base flows have had any noticeable impact on ACWA visitation rates and finds, as shown in **Figures 2a** through **2c,** that there is no obvious relationship between decreases in Aravaipa Creek base flows and the number of people that have visited ACWA. In fact, elevated base flows have, at times, seemed to decrease the number of visitors.

5.1.3 Annual flow

BLM's annual flow claim to Aravaipa Creek is based on 28 years of record collected at USGS gage 09473000 between 1932 and 1984. Over that period, annual streamflow data were not available during 1941 and from 1943 through 1967 (25 years). In **Section 2.3.1**, Plateau evaluates the effect of this missing data by extending the gage's period of record through correlation to a nearby gage with a longer record. Results from the record extension are shown in **Figure 3** and listed in **Table 12**. These results indicate that, when the missing years of record are added, the average annual flow at USGS gage 09473000 is estimated to decrease from 24,600 AF to 21,100 AF, a reduction of about 14%. This demonstrates that if the USGS gage site is used to monitor annual flows for ACWA, BLM's claims are probably too high.

BLM's annual flow claims would be further reduced if median values are used in place of averages. For streams like Aravaipa Creek, which occasionally exhibit years of extremely high flow, medians better represent typical streamflow conditions. Using BLM original period of record, the median annual flow in Aravaipa Creek reduces to 18,900 AF, substantially less than its claimed average annual flow of 24,600 AF. If Plateau's extended period of record is used, the median flow reduces further to only 16,400 AF. Neither the United States nor its experts explain why BLM calculate average rather than median annual flows for its claims and Plateau reserves the right to evaluate additional evidence on this topic and revise its opinions accordingly.

Plateau confirms in **Section 2.3.2** that the lower annual flows during the years of missing record are likely caused by drought (see **Figure 4**). Increased human demands for irrigation and mining during this period likely caused these flows to be even lower than Plateau's estimates. BLM did not evaluate either factor and both appear to have peaked during the period when the USGS gage was inoperable.

As with flood events and base flow, annual flows vary spatially along Aravaipa Creek. Plateau analyzes what effect this has on BLM's federal reserved right claims in **Section 2.3.3**. It estimates that the average annual flow in Aravaipa Creek at the east ACWA boundary totals about 16,100 to 16,400 AFA or about 34% below BLM's claim when the extended period of record for the gage is used. At the west end of ACWA, this difference reduces to about 19% with an average annual flow estimated to total about 19,800 to 19,900 AFA. As shown in **Table 12**, Plateau recommends that BLM's average annual flow claims to Aravaipa Creek be reduced at least by the amounts discussed above and its measuring point clearly specified by the Special Master. Further reductions in these values would be required if median annual flows are substituted for the averages that were used.

5.1.4 Unimpounded flood flow

BLM also claims unimpounded flood flows in Aravaipa Creek for ACWA. As described in **Section 2.3.4**, BLM calculates these claims by subtracting its base flow claim from its

annual flow claim. The limitations of BLM's base flow and annual flow claims are noted above and carry over here.

Table 12 shows how BLM's unimpounded federal reserved right claims are reduced if (i) the period of record for the USGS gage is extended; (ii) changes in flow along Aravaipa Creek are accounted for; and (iii) BLM's instream flow rights are substituted in place of its base flow claims. The latter is justified since the instream flow rights have already been appropriated and predate the reservation. Making these recommended corrections, Plateau estimates that BLM's claims to unimpounded flood flow in Aravaipa Creek are substantially reduced. Unimpounded flood flows decline from 15,156 AFA to, at most, between 5,300 and 5,600 AFA at the east ACWA boundary and between 9,000 and 9,100 AFA at the west boundary. Use of median annual flows in place of averages results in even lower unimpounded flood flows.

5.2 Springs

BLM claims federal reserved rights to 14 springs in ACWA with a total claimed amount of 182.94 AFA. Plateau completed a preliminary review of these claims and summarizes its findings in **Table 10**. It notes that all but two springs are associated with other water right filings and most of these have priorities that predate the reservation. As such, all or a portion of the water from the springs may be already appropriated and unavailable to meet BLM's federal reserved right claims for ACWA.

Plateau's initial evaluation of the location of the ACWA springs found only one minor discrepancy. However, results from its review of claimed amounts are more problematic. In some cases, the claimed amount for a spring is higher than prior water right filings and in other cases it is the same or lower. The consequence of this difference is that, depending on the spring, there may or may not be unappropriated water available to meet BLM's recent claims. It is also unclear to Plateau, based on its review of available discharge measurements, whether BLM's claimed amounts are representative. That is, would collection of more (or any) discharge measurements cause these amounts to be updated?

Plateau recommends further analysis of BLM's spring claims including a clear explanation by BLM of the basis for each of claim and the effect that prior filings have on the availability of unappropriated water for these claims. Note that the Special Master directed ADWR in August 2012 to evaluate all state-law based and federal reserved right claims held by the United States in ACWA. ADWR's report is due February 2014 and may shed further light on these claims.

5.3 Ponds

BLM also claims federal reserved rights to 12 ponds in ACWA with a total capacity of 16.09 AF. Plateau completed a preliminary review of these claims as well and its findings are summarized in **Table 11**. All ponds were found to be associated with other water right filings with priorities that predate the reservation. Like the spring claims, this indicates that all or a portion of the claimed pond capacities may already be appropriated and unavailable to meet BLM's federal reserved right claims to ACWA.

Plateau only notes two minor discrepancies regarding the location of a claimed pond which it recommends that BLM and/or ADWR resolve. Results from Plateau's review of claimed pond capacities are more problematic. In some cases, claimed capacities are higher than prior filings and in other cases they are the same or lower. Therefore, depending on the pond, there may or may not be unappropriated water to meet BLM's federal reserved right claim.

Some claimed pond capacities may also be inaccurate. Using recent aerial photography, Plateau determined that the claimed capacity of a few ponds appears too high. Field inspection by ADWR is recommended to verify the current condition and capacity of all ponds. BLM should also explain the basis for each pond and the effect that prior filings have on the availability of unappropriated water.

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TABLES

TABLE 1 - ESTIMATED MAGNITUDE AND FREQUENCY OF ARAVAIPA CREEK FLOOD FLOWS AT USGS GAGE 09473000

DATA SOURCE	PERIOD OF RECORD	ESTIMATION TECHNIQUE	FLOOD MAGNITUDE (cfs)[1]				
			Return Period (year)				
			2	10	25	50	100
BLM's 2012 Federal Reserved Right Claim and Swanson (2013, pp.5-6)[2]	Partial (1932-1984; 28 calendar years)	Not specified	4,540	15,600	26,300	37,000	50,700
Plateau (this study)	Full (1919-2012; 62 water years)	Bulletin 17B[3]	3,816	11,950	18,490	24,660	32,060[5]
	Partial (1933-1985; 30 water years)[4]		3,953	12,140	18,580	24,560	31,660
USGS (1998, p.364)	Partial (1919-1996; 46 water years)	Log Pearson Type III	3,980	11,500	16,800	21,600	26,900

Notes:

[1] Instantaneous peak discharge in cubic feet per second (cfs).

[2] According to the federal reserved right claim, these values are "estimated required flood flows".

[3] Calculated by Plateau Resources using the USGS (2007) computer program PeakFQWin. See **Appendix B** for program output reports.

[4] Similar period of record as used by BLM in its claim; difference due to use of water vs. calendar years.

[5] USGS (2008a, p.41) estimated that the return period for the August 1, 2006 Aravaipa Creek peak flow of 28,000 cfs was "slightly less than the 100-year flood."

TABLE 2 - EFFECT OF DRAINAGE AREA ON ARAVAIPA CREEK FLOOD FLOWS

DRAINAGE AREA (square miles)[1]	LOCATION	ESTIMATED FLOOD MAGNITUDE (cfs)[2,3]				
		Return Period (year)				
		2	10	25	50	100
411	East boundary of ACWA	2,890	9,220	14,200	18,800	24,300
503	West boundary of ACWA	3,500	10,800	16,500	21,900	28,300
537[4]	USGS Gage 09473000	3,816	11,950	18,490	24,660	32,060

Notes:

[1] Plateau calculated drainage areas using Shuttle Radar Topography Mission (SRTM) elevation data as input to a digital elevation model developed in ArcGIS.

[2] Instantaneous peak discharge in cubic feet per second (cfs).

[3] Plateau calculated flood magnitudes at the east and west ACWA boundaries using Version 6 of the USGS (2012) National Streamflow Statistics Program for estimating statistics at gaged and ungaged sites. Weightings were applied to both locations as suggested by the program and the gage's full (62-year) period of record was used. See **Appendix C** for program output reports. See **Table 1** for Plateau's methodology for estimating flood magnitudes at the USGS gage.

[4] In December 2008, USGS moved its gage about 0.7 miles downstream to a fish barrier constructed across Aravaipa Creek. USGS (2013) still reports the same drainage area for the gage at 537 square miles. Plateau calculated the drainage area for the old gage site at 542 square miles and the new gage site at 543 square miles.

TABLE 3 - COMPARISON BETWEEN BLM'S FEDERAL RESERVED RIGHT CLAIMS FOR ACWA BASEFLOWS AND ARAVAIPA CREEK INSTREAM FLOW CERTIFICATES

CLAIM / RIGHT			MEASUREMENT POINT		PRIORITY DATE	MONTHLY FLOW (in cfs)[3]												BASIS
No.	Holder	Status[1]	Description	Map No.[2]		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec	
39-68704	BLM	F	Not specified (Aravaipa Creek within ACWA)	---	8/28/1984	16	18	18	13	10	6	10	14	12	11	12	17	Median of daily means measured at USGS gage 0947300 for each month over the period of record (1932-40, 42, 67-84).
33-87114	BLM	A	Not specified (Aravaipa Creek within ACWA)	---	6/1/1981	Continuous 15 cfs including 10 cfs for wildlife and fisheries and 5 cfs for ecosystem maintenance and aesthetic recreational values												Not stated
		P	Near east boundary of ACWA at BLM's East End Wilderness Gage	2		20	25	20	10	10	9	10	20	11	15	10	20	Average daily flows requested by BLM (1988a, p.9-10) represent "the minimal amounts of flow needed to maintain and preserve the character of water-dependent values in the (ACWA)".
		C																ADWR (1995) review of permit compliance
33-95490	TNC	A	East of ACWA at Old School House Gage	1	10/31/1990	16	18	18	16	14	14	14	15	14	15	15	17	Hardy and others (1990) report prepared for TNC on instream habitat needs of native fish; claims equal to 80% of median mean daily flow for month at gage if within 90% of optimal fish flow requirement.
		P																ADWR (1992a) review of application and supporting materials.
		C																ADWR (1995) review of permit compliance.
33-95489	TNC	A	Near east boundary of ACWA at BLM's East End Wilderness Gage	2	10/31/1990	19	21	22	19	18	17	17	18	18	18	18	20	Hardy and others (1990) report prepared for TNC on instream habitat needs of native fish; claims equal to 80% of median mean daily flow for month at gage if within 90% of optimal fish flow requirement.
		P																ADWR (1992a) review of application and supporting materials.
		C																ADWR (1995) review of permit compliance.
33-95488	TNC	A	Near west boundary of ACWA at BLM's West End Wilderness Gage	3	10/31/1990	21	23	32	21	18	17	18	19	18	19	19	22	Hardy and others (1990) report prepared for TNC on instream habitat needs of native fish; claims equal to 80% of median mean daily flow for month at gage if within 90% of optimal fish flow requirement.
		P				20.4	21.9	19.7	13.1	18	15.2	18	19	18	13.4	15.7	17.2	ADWR (1992a) review of application and supporting materials.
		C																ADWR (1995) review of permit compliance.
33-95771	TNC	A	West of ACWA at USGS Gage 09473000	4	10/31/1990	15	16	19	16	13	12	14	14	13	12	14	15	Hardy and others (1990) report prepared for TNC on instream habitat needs of native fish; claims equal to 80% of median mean daily flow for month at gage if within 90% of optimal fish flow requirement.
		P									9.3							ADWR (1992b) review of application and supporting materials.
		C																ADWR (1995) review of permit compliance.

Notes:

[1] A = application, C = certificate, F = federal reserved right claim, and P = permit.

[2] See **Figure 1** for map of gage locations.

[3] Shading indicates federal reserved right claim exceeds instream flow certificate; flows in cubic feet per second (cfs).

TABLE 4 - COMPARISON OF ARAVAIPA CREEK MEDIAN MONTHLY STREAMFLOWS AT USGS GAGE 0947300 TO BLM's FEDERAL RESERVED RIGHT CLAIMS[1]

YEAR	MEDIAN MONTHLY FLOW (in cubic feet per second)											
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1931	---	---	---	---	6	7	12	20	17.5	12	16	28
1932	23	34	22	18	13	9	11	16	8	15	12	19
1933	17	22	16	13.5	10	8	13	5	8.5	13	11.5	12
1934	10	10.5	12	9	6	5	5	11	4.5	8	11	17
1935	31	34	33	17	10	5	3	41	21.5	10	14	16
1936	15	30	21	14	8	5	12	14	16.5	12	11.5	16
1937	37	21	16	12	7	4	7	13	12.5	8	11.5	14
1938	13	15	16	11	6	4	9	8	4	7	10	12
1939	11	17	11	9	4	2	5	11	4	6	8.5	11
1940	10	13	10	7	6	3	3	2	8.5	7	10	17
1941	30	61	70	33.5	19	10.5	---	---	---	61	23	33
1942	30	20	27	25	16	8.95	15	11	20.5	14	13	22
1943-45	*No data collected*											
1946	---	---	---	---	---	---	5.97[2]	---	---	---	---	---
1947-50	*No data collected*											
1951	---	---	---	---	---	---	0[2]	---	---	---	---	---
1952	---	---	---	---	---	2.65[2]	---	---	---	---	---	---
1953	---	---	---	---	---	---	2.72[2]	---	---	---	---	---
1954	9.29[2]	---	11.2[2]	---	---	1.44[2]	---	---	---	---	---	---
1955-56	*No data collected*											
1957	---	---	---	---	---	1.11[2]	---	---	---	---	---	---
1958	9.44[2]	---	---	---	---	1.35[2]	---	---	---	---	---	---
1959	---	---	---	---	---	0.92[2]	---	---	---	---	---	---
1960	---	---	11.7[2]	---	---	---	---	---	---	---	---	---
1961	*No data collected*											
1962	---	---	---	---	---	2.35[2]	---	---	---	---	---	---
1963	---	---	---	---	---	---	0.43[2]	---	---	---	---	---
1964	---	---	---	---	---	1.02[2]	---	---	---	---	---	---
1965	*No data collected*											
1966	---	---	---	---	---	5.85	6.3	18	22	13	17	17
1967	19	16	13	12	9.2	5.35	11	13	12.5	10	12	53
1968	13	9.9	28	19	17	12.5	13	15	15	12	16.5	15
1969	16	11	17	12	10	5.85	7.5	14	16	9	11	17
1970	15	12.5	15	11.5	8.6	5.2	5	10	9.1	7.1	11	9.8
1971	10	12	9.2	9.7	6.5	3.55	2.5	20	8.35	11	15	32
1972	15	11	12	8.05	2.9	10.5	5	3.4	20	22	18.5	15
1973	18	21	43	26.5	16	15.5	8.2	10	5.35	12	16.5	20
1974	14	17	19	10	6.9	3.25	18	9.6	15	9.2	13	14
1975	13	15	18	12.5	9.6	3.4	2.6	5.9	7.5	7.5	9.3	13
1976	12	11	10	7	5.3	2.75	2.5	6.2	7.7	7.1	8.85	8.6
1977	14	11	10	7.4	5	1.8	4.6	2	5	5.5	9.3	8.7
1978	10	49.5	65	14	13	7.15	9.5	14	9.6	12	20	25
1979	166	107.5	42	45	38	25	23	22	25	25	27	28
1980	28	55	38	25	21	17	17	20	18.5	17	20	20
1981	20	20.5	18	18	15	8	13	8	10	12	11	16
1982	25	22.5	25	14	12	6	6	20	9.4	12	18	20
1983	17	54.5	95	35	20	12.5	20	30	29	45	47.5	45
1984	50	38	30	32.5	30	30.5	75	90	56	32	30	62
1985	70	72.5	49	40.5	33	30	26	42	22.5	30	30	26
1986	26	39	80	27	26	19	21	19	21.5	24	24	34
1987	30	28.5	42	27	26	15	22	22	24.5	18	20	28
1988	23	25	23	19	15	13	19	42	15	15	13	20
1989	31	11	13	15	7	5	9.8	18	9.6	9.9	16	17
1990	17	20	18	15	12	9.5	28	31	14	12	12	20
1991	26	19	65	27	18	15	15	21	21	20	23.5	29
1992	32	45	37	29	28	22	19	29	22	22	29	45
1993	434	97	72	51.5	40	36	33	33	37.5	31	33	32
1994	30	42	31	24.5	19	13	13	23	19	17	23	23
1995	60	63.5	39	30.5	30	21	17	19	22	22	26	24
1996	26	29	25	22	11	9	13	11	14.5	16	17	21
1997	21	18	20	15	8.3	5.55	3.9	12	12	12	14	2.7
1998	5.3	153.5	36	34.5	19	12	15	25	17.5	17	21	32
1999	31	22	25	18	13	9.55	29	26	16	13	16	17
2000	15	18	17	11	6.9	6.5	9.9	15	8.6	20	32	19
2001	23	23	19	14.5	10	5.5	8.1	10	8.6	10	13	16
2002	15	16	16	10.5	4.6	2.4	13	7.9	7.8	8.5	11	14
2003	16	28.5	22	12	6.5	3.5	3.3	19	16	4.59[2]	13.4[2]	16[2]
2004	15.5[2]	12.7[2]	40.6[2]	13.3[2]	3.5[2]	1.92[2]	0.66[2]	7.97[2]	---	5.52[2]	10.4[2]	15[2]
2005	14.8-235[2]	17.3[2]	17.1[2]	9.7[2]	4.25[2]	1.12[2]	0.476[2]	11.4-3000[2]	12.7[2]	7.5	10.5	15
2006	12	13	11	8.1	3.3	0.72	6.9	42	16	16	13	15
2007	16	17	16	14	11	7.15	5.3	15	7.8	8.8	12	26
2008	26	31	15	10	8.3	6.15	34	14	8.55	6.9	14	14
2009	16	15	13	9.4	6.5	2.9	9.6	4.2	10.5	8.4	11	12
2010	13	25.5	31	18.5	14	5.7	6	15	10	11	14	18
2011	17	17	17	12	7.7	3.25	13	7.9	9.8	8.9	12	14
2012	13	13	12	8.15	3.3	1.4	10	7.2	6.6	6.6	11	13
2013	13	12	12	7.95[3]	2.7[3]	0.02[3]	8.5[3]	12[3]	14[3]	---	---	---
BLM Claims	**16**	**18**	**18**	**13**	**10**	**6**	**10**	**14**	**12**	**11**	**12**	**17**

= median flow >50% below claim
= median flow 25 to 50% below claim
= median flow 0 to 25% below claim
= median flow 0 to 25% above claim
= median flow 25 to 50% above claim
= median flow >50% above claim

"---" = data not available

Notes:

[1] Data from USGS (1977 and 2013); gage was moved to a fish barrier about 0.7 miles downstream in December 2008.

[2] Miscellaneous measurement; not a median value.

[3] Provisional data subject to revision.

TABLE 5 - MONTHLY CHANGE IN BASE FLOW ALONG ARAVAIPA CREEK FROM THE EAST BOUNDARY OF ACWA TO USGS GAGE 09473000

MONTH	PERIOD OF RECORD	NUMBER OF INSTANTANEOUS DISCHARGE MEASUREMENTS AT THE EAST END GAGE SITE[1]	TYPICAL DOWNSTREAM CHANGE IN FLOW FROM EAST END GAGE SITE TO USGS GAGE 09473000[2,3]	
			cfs	%
January	1982-2013	38	3	11
February		42	6	28
March	1979-2013	39	4	17
April		45	1	3
May		42	-2	-7
June		49	-4	-24
July	1979-2012	48	-3	-20
August		41	1	7
September	1982-2012	39	-2	-8
October	1979-2012	37	-1	-6
November	1982-2012	42	-1	-4
December	1980-2012	46	2	13

Notes:

[1] Instantaneous discharge measurements were taken by BLM and TNC in support of their instream flow claims.

[2] Changes in flow from the East End site to the USGS gage were calculated by subtracting the upstream instantaneous discharge measurement from the same day USGS daily mean flow. The median of these changes was calculated for each month to represent typical conditions. Medians are presented in cubic feet per second (cfs) and as a percentage (%). Percentages were calculated by dividing the change in flow by the upstream value.

[3] Green values indicate a downstream increase in flow and red values indicate a downstream decrease in flow.

TABLE 6 - MONTHLY CHANGE IN BASE FLOW ALONG ARAVAIPA CREEK FROM THE WEST BOUNDARY OF ACWA TO USGS GAGE 09473000

MONTH	PERIOD OF RECORD	NUMBER OF INSTANTANEOUS DISCHARGE MEASUREMENTS AT THE WEST END GAGE SITE[1]	TYPICAL DOWNSTREAM CHANGE IN FLOW FROM WEST END GAGE SITE TO USGS GAGE 09473000[2,3]	
			cfs	%
January	1982-2011	23	**0**	**0**
February	1985-2012	21	**-1**	**-7**
March	1981-2013	28	**-1**	**-2**
April	1981-2012	27	**-2**	**-7**
May	1983-2012	24	**-5**	**-17**
June	1981-2012	28	**-5**	**-26**
July		26	**-3**	**-18**
August	1982-2012	25	**0**	**0**
September	1981-1996	26	**-5**	**-20**
October	1981-2011	29	**-2**	**-12**
November		22	**-2**	**-12**
December	1980-2011	21	**3**	**18**

Notes:

[1] Instantaneous discharge measurements were taken by BLM and TNC in support of their instream flow claims.

[2] Changes in flow from the West End site to the USGS gage were calculated by subtracting the upstream instantaneous discharge measurement from the same day USGS daily mean flow. The median of these changes was calculated for each month to represent typical conditions. Medians are presented in cubic feet per second (cfs) and as a percentage (%). Percentages were calculated by dividing the change in flow by the upstream value.

[3] Green values indicate a downstream increase in flow and red values indicate a downstream decrease in flow.

TABLE 7 - HISTORIC CHANGES IN IRRIGATION ALONG ARAVAIPA CREEK

YEAR	IRRIGATED AREA UPSTREAM OF USGS GAGE 09473000 (in acres)						METHOD	SOURCE
	Above ACWA			Below ACWA				
	Active	Fallow	Idle	Active	Fallow	Idle		
1921	250	20		105	<5		Field surveys[1]	Arizona State Water Commissioner (1921)
circa 1930	340 to 380			"up to 300 acres may have been under cultivation"			Historic accounts	Hadley (1991, pp.210-221)
1941	"Diversions above station for irrigation of about 700 acres"						Not specified	USGS (1947, p.349)
1950-1970	680 to 740			Not provided			Historic accounts	Hadley (1991, pp.210-217)
1972-1973	850						Analysis of satellite imagery[1]	University of Arizona (1974)
1990	700	110	110	70			Field surveys and analysis of aerial photos	ADWR (1991, pp. 144, 311-312, 506, and C-76)
2010	280	270	320	20	10	10	Analysis of aerial photos[2]	Plateau Resources (this study)

Notes:

[1] Plateau determined acreages by digital planimetry of existing maps.

[2] Plateau determined acreages by digital planimetry of aerial photographs.

TABLE 8 - EFFECT OF DRAINAGE AREA ON AVERAGE ANNUAL STREAMFLOWS IN ARAVAIPA CREEK

LOCATION	SITE	PERIOD OF RECORD[1]	DRAINAGE AREA (square miles)[2]	RATIO OF UNGAGED DRAINAGE AREA TO GAGED SITE	EXPONENT USED TO RELATE SITE DISCHARGES	AVERAGE ANNUAL DISCHARGE (acre-feet)	NOTES
East boundary of ACWA	Ungaged	Original	411	0.77	0.97 to 1.04[3]	18,800 to 19,100	Discharge estimated using the drainage-area ratio method which computes flow at an ungaged sited near a gaged site (index station) using the ratio in drainage areas and index station flow data.[3]
		Extended				16,100 to 16,400	
West boundary of ACWA		Original	503	0.94		23,100 to 23,200	
		Extended				19,800 to 19,900	
USGS Gage 09473000	Gaged	Original	537	---		24,600	Discharge equals the average of the mean annual flows reported by USGS (2013) for the original period of record.
		Extended				21,100	Discharge equals the average of the mean annual flows if the period of record for gage 09473000 is extended through regression with gage 09468500.

Notes:

[1] The original of period used by BLM in its ACWA federal reserved right claims ran from 1932 through 1984 but missed 25 intervening years (1941 and 1943 through 1966) when the gage was inoperable. Plateau's extended period of record includes those missing years but covers the same period through 1984. It also includes two earlier years (1930 and 1931).

[2] Plateau calculated drainage areas for the east and west ACWA boundaries using Shuttle Radar Topography Mission (SRTM) elevation data as input to a digital elevation model developed in ArcGIS. The drainage area for gage 09473000 was reported by USGS (2013b).

[3] See USGS (1990, pp.21-23) for further discussion of their application of the drainage-area ratio method near Aravaipa Creek. USGS found that the exponent used to estimate annual discharges at ungaged sites based on drainage area ranged from 0.97 to 1.04 using gaged stations with mean basin elevations of less than 7,500 feet. The mean basin elevation for gage 0947300 is approximately 4,530 feet (USGS, 1998, p.363).

TABLE 9 - CALCULATION OF UNIMPOUNDED FLOOD FLOWS

SOURCE	LOCATION	ANNUAL FLOW (AFA)	BASE FLOW (AFA)	UNIMPOUNDED FLOOD FLOW (AFA)[1]
BLM claims	ACWA	24,600	9,444	15,156
Plateau (this report)	USGS Gage 09473000	21,100[2]	10,840[3]	10,300
	West ACWA boundary	19,800 to 19,900[2]		9,000 to 9,100
	East ACWA boundary	16,100 to 16,400[2]		5,300 to 5,600

Notes:

[1] Calculated by subtracting base flow from annual flow.

[2] See **Table 8** for explanation of Plateau's annual flow estimates.

[3] Annual volume specified in BLM's instream flow certificate for Aravaipa Creek (No. 87114).

TABLE 10 - PRELIMINARY ANALYSIS OF ACWA SPRING CLAIMS

NAME	DATA SOURCE[1]	LOCATION[2]				AMOUNT[3,4]	TYPE	PRIORITY DATE	NOTES
		T	R	S	Q's				
Buggar Spring	FRR claim	6S	18E	8	NW,SE	9.05 AFA	Flow	1984	
	CWR 308 (revised)					0.05 AFA (15,000 GPA)	Use	1929	BLM is current right holder
	CWR 308 (original)					9.05 AFA (1/80 CFS)			Campbell was original holder
East Booger Spring	FRR claim	6S	18E	10	SW,SE	8.10 AFA	Flow	1990	
	CWR 95401					0.01 AFA (3,000 GPA)	Use	1990	BLM is current right holder
	39-14494					0.05 AFA		1910	BLM claim
						8 AFA (5 GPM)	Flow		
	ADWR (2008a)	---				8 AFA (5 GPM)		---	July 1986 discharge measurement
Goat Spring[5]	FRR claim	6S	18E	25	NW,SW	1.61 AFA	Flow	1984	
	36-61123					0.13 AFA (42,660 GPA)	Use	1883	Amended BLM claim
	39-2643					0.33 AFA		1867	Original Salazar claim
	39-14492					0.096 AFA		1926	BLM PWR 107 claim
						1.6 AFA (1 GPA)	Flow		
	ADWR (2007 and 2008a)					1.6 to 48 AFA (about 1 to 30 GPM)		---	August 1986 and November 2002 discharge measurements, respectively
Hanging Spring	FRR claim	6S	19E	18	NW,NW	80 AFA	Flow	1990	
	ADWR (2008a)	---				160 AFA (100 GPM)		---	April 1987 discharge measurement
Janette Spring	FRR claim	6S	19E	7	SW,NE	8.06 AFA	Flow	1990	
	ADWR (2008a)	---				6.4 AFA (4 GPM)		---	April 1991 discharge measurement
Lower Stone Spring	FRR claim	6S	18E	27	NW,NW	0.17 AFA	Flow	1990	
	CWR 85308					0.84 AFA (273,750 GPA)	Use	1980	BLM is current right holder
	36-100198					0.17 AFA (54,420 GPA)		1883	BLM claims
	39-6876					0.17 AFA			
Lupie Seep	FRR claim	6S	18E	27	NW,SW	0.10 AFA	Flow	1990	
	33-95452					0.10 AFA (31,281 GPA)	Use	1990	BLM claims
	36-100196					0.10 AFA (31,300 GPA)		1883	
McRae Spring	FRR claim	6S	18E	35	NE,NE	0.13 AFA	Flow	1990	
	36-105088					0.13 AFA (43,280 GPA)	Use	1917	BLM claim
	ADWR (2008a)	---				16 AFA (10 GPM)	Flow	---	November 1999 discharge measurement
Natural Boundary Spring	FRR claim	6S	19E	7	SW,SW	15.2 AFA	Flow	1990	
	36-104905				SE,SW	0.14 AFA (47,000 GPA)	Use	1883	BLM claim
	USAV2-3651,3652	---				15.0 AFA (9.4 GPM)	Flow	---	October 2011 discharge measurement
	ADWR (2008a)					9.6 AFA (6 GPM)			April 1987 discharge measurement
North Booger Spring	FRR claim	6S	18E	10	NW,SE	0.80 AFA	Flow	1990	
	CWR 95400					0.02 AFA (5,000 GPA)	Use	1990	BLM is current right holder
	39-14493					0.05 AFA		1910	BLM claim
						0.8 AFA (0.5 GPM)	Flow		
	ADWR (2008a)					0.64 AFA (0.4 GPM)		---	July 1986 discharge measurement
Purgatory Spring[5]	FRR claim	6S	18E	13	NW,NW	0.80 AFA	Flow	1984	
	36-20685					0.10 AFA (32,000 GPA)	Use	1883	BLM claim
	39-14444					0.70 AFA		1926	BLM PWR 107 claim
	ADWR (2007)					0.8 AFA (0.5 GPM)	Flow	---	April 1988 and November 2002 discharge measurements
Rock Tub Spring	FRR claim	6S	19E	7	NW,NE	0.80 AFA	Flow	1990	
	36-104948					0.49 AFA (160,000 GPA)	Use	1883	BLM claim
	ADWR (2008a)	---				0.8 AFA (0.5 GPM)	Flow	---	April 1991 discharge measurement
Saltuna Spring[5]	FRR claim	6S	18E	13	NW,SE	58 AFA	Flow	1990	
	39-14443					10 AFA	Use	1926	BLM claim
						24 AFA (15 GPM)	Flow		
	USAV2-3647,3648	---				58 AFA (36.4 GPM)	Flow	---	December 2012 discharge measurement
	ADWR (2008a)					8 to 24 AFA (5 to 15 GPM)			April 1987 and November 2002 discharge measurements
Stone Cabin Spring	FRR claim	6S	18E	27	NW,SW	0.12 AFA	Use	1990	
	36-37292					0.12 AFA (39,750 GPA)		1927	Amended BLM claim
	39-6877					0.28 AFA		1867	

Notes:

[1] FRR = BLM's Federal Reserved Right Claim for ACWA; "CWR" = Certificate of Water Right; "33" = application to appropriate surface water; "36" = statement of claim; "39" = statement of claimant; ADWR (2008a) is a spring database that includes 2005 discharge files from BLM's Safford District Office; ADWR (2007) is a report analyzing PWR claims (see note 5); and USAV2 indicates a document disclosed by the United States.

[2] Location at the point of diversion/spring source.

[3] AFA = acre-feet per year; GPA = gallons per year; and GPM = gallons per minute.

[4] Discharge measurements were originally reported in GPM and converted to AFA by assuming a constant flow rate all year.

[5] BLM also filed Public Water Reserve No. 107 (PWR) claims for Goat, Purgatory and Saltuna springs with a 1926 priority date. See ADWR (2007) for further review

TABLE 11 - PRELIMINARY ANALYSIS OF ACWA POND CLAIMS

NAME	DATA SOURCE[1,2]	LOCATION				CAPACITY (AF)[3]	PRIORITY DATE	NOTES
		T	R	S	Q's			
Adalfo Tank	FRR claim	6S	18E	24	SW,SE	0.33	1984	
	38-61134 (certificated)					0.33	1963	BLM is current certificate holder; known as Turkey Creek Tank
	38-19225					1		BLM is current claim holder; known as Adafo Tank
	Aerial photo					---		Ponds appears to cover less than 0.1 acres
Basin Tank	FRR claim	6S	18E	26	NE,SE	0.06	1990	
	38-88417					0.33	1955	BLM is current claim holder
	38-61133					0.33		Salazar was prior claim holder
	Aerial photo					---		Ponds appears to cover less than 0.1 acres
Bill's Tank	FRR claim	6S	18E	27	SE,NE	0.5	1990	
	38-88416					0.5	1948	BLM is current claim holder
	38-61138					0.33		Salazar was prior claim holder
	Aerial photo					---		Ponds appears to cover about 0.1 acres
Brown's Tank	FRR claim	7S	18E	11	SE,NW	2.22	1990	
	CWR 3473					0.5	1970	Salazar was original certificate holder
	38-88425					0.5	1971	BLM is current claim holder
	Aerial photo					---		Pond appears to cover about 0.1 acres
Cave Pasture Tanks	FRR claim	6S	18E	7	NE,SW	0.09	1990	
	38-88515					0.13	1952	Tank 1; BLM is current claim holder
	38-88516					0.22	1952	Tank 2; BLM is current claim holder
	Aerial photo	Inconclusive				---		Pond not clearly visible on aerial photo
Daggar Draw Tank	FRR claim	6S	18E	30	NE,NW	3.25	1990	
	CWR 3940					1.5	1969	BLM is current certificate holder
	38-88527					3.44	1969	BLM is current claim holder
	Aerial photo	6S	18E	30	NW,NE	---		Pond appears to cover about 0.4 acres
Houston Tank	FRR claim	6S	18E	26	NE,SW	2.38	1990	
	CWR 87291					0.8	1982	BLM is current certificate holder
	39-12029					0.18	1983	ASLD was former claimant
	Aerial photo					---		Pond appears to cover less than 0.1 acres
McNair Tank	FRR claim	6S	18E	23	SW,NW	3.08	1990	
	CWR 3471					3.0	1965	Salazar was original certificate holder
	38-88439					3	1953	BLM is current claim holder
	Aerial photo					---		Pond appears to cover about 0.4 acres
Mesa Tank #1	FRR claim	6S	18E	8	SE,NE	1.4	1984	
	38-88587					2.84	1934	BLM is current claim holder
	Aerial photo					---		Pond appears to cover about 0.5 acres
Mesa Tank #3	FRR claim	6S	18E	8	NE,SE	0.35	1984	
	38-88589					0.39	1934	BLM is current claim holder; known as "Mesa Tank #1"
	38-88793					0.35	1970	BLM is current claim holder; known as "Mesa Tank #2"
	Aerial photo					---		The one pond at this location appears to cover about 0.4 acres
Mescal Tank	FRR claim	6S	19E	31	NW,SW	0.03	1990	
	38-88245	6S	19E	31	NE,SW	0.1	prior to 1972	BLM is current claim holder
	Aerial photo	Inconclusive				---		Pond not clearly visible on aerial photo
Ralph's Tank	FRR claim	7S	18E	12	SW,NW	2.13	1990	
	CWR 3472					0.33	1970	Salazar was original certificate holder; known as Wire Corral Tank
	38-88426					0.33	1971	BLM is current claim holder; known as Wire Corral Tank
	Aerial photo					---		Pond appears to cover about 0.4 acres
Tank Canyon Reservoir	FRR claim	6S	18E	11	SW,NW	0.27	1990	
	CWR 658					2	1935	Sanford was the original certificate holder
	38-88405					1.0	1945	BLM is current claim holder; previously known as Cement Dam Tank
	Aerial photo					---		Pond appears to cover about 0.1 acres

Notes:

[1] FRR = BLM's Federal Reserved Right claim to ACWA; "CWR" = Certificate of Water Right; "38" = stockpond claim; "39" = statement of claimant; and aerial photos were taken in August 2010.

[2] Other statements of claimant associated with these stockpond are not shown if their basis of claim is already listed here and the information is the same.

[3] AF = acre-feet; quantities reflect maximum pond capacities.

TABLE 12 - PLATEAU's RECOMMENDED FEDERAL RESERVED RIGHTS TO ACWA FOR ARAVAIPA CREEK BASED ON ITS HYDROLOGIC REVIEW OF BLM's CLAIMS[1]

***FLOOD EVENTS*:**

SOURCE	REPORT REFERENCE	LOCATION	FLOOD MAGNITUDE (cfs)				
			Return Period (year)				
			2	10	25	50	100
BLM FRR claim	Appendix A	ACWA	4,540	15,600	26,300	37,000	50,700
Plateau recommendation	Table 1[2]	USGS Gage 09473000	3,816	11,950	18,490	24,660	32,060
	Table 2[2,3]	West ACWA boundary	3,500	10,800	16,500	21,900	28,300
		East ACWA boundary	2,890	9,220	14,200	18,800	24,300

***BASE FLOW*:**

SOURCE	REPORT REFERENCE	LOCATION	MEDIAN MONTHLY FLOW (cfs)											TOTAL FLOW (AFA)
			Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
BLM FRR claim	Appendix A	ACWA	16	18	18	13	10	6	10	14	12	11	12	17	9,444
BLM instream flow rights	Table 3	East ACWA boundary	20	25	20	10	10	9	10	20	11	15	10	20	10,840
Plateau recommendation	Section 2.2.1[4]		0	0	0	0	0	0	0	0	0	0	0	0	0

***ANNUAL FLOW*:**

SOURCE	REPORT REFERENCE	LOCATION	PERIOD OF RECORD[5]	AVERAGE AMOUNT (AFA)
BLM FRR claim	Appendix A	ACWA	Original	24,600[7]
Plateau recommendation	Table 8	USGS Gage 09473000	Extended	21,100[7]
		West ACWA boundary		19,800 to 19,900[8]
		East ACWA boundary		16,100 to 16,400[8]

UNIMPOUNDED FLOOD FLOW:

SOURCE	REPORT REFERENCE	LOCATION	PERIOD OF RECORD[5]	AVERAGE AMOUNT (AFA)[6,8]
BLM FRR claim	Appendix A	ACWA	Original	15,156
Plateau recommendation	Table 9	USGS Gage 09473000	Extended	10,300
		West ACWA boundary		9,000 to 9,100
		East ACWA boundary		5,300 to 5,600

Notes:

[1] Plateau does not evaluate the ecological basis for BLM's claims which, according to SWCA's analysis, also overestimate the minimum needs to meet the primary purpose of the reservation. AFA = acre-feet per year; cfs = cubic feet per second; and FRR = federal reserved right.

[2] Calculated using the full period of record (1919-2012; 62 water years) available for USGS gage 09473000.

[3] Flood events are estimated at the east and west ACWA boundaries using the USGS (2012) National Streamflow Statistics Program. Flood estimates for both locations are weighted using the full period of record from USGS gage 09473000.

[4] If BLM's instream flow right exceeds its FRR claim, then Plateau recommends a FRR of 0 cfs and 0 AFA. For the three months when the latter exceeds the former (April, September and November), the FRR could equal the difference. However, this assumes that no upstream water claims exist that could be perfected with a priority date earlier than the reservation, which is unlikely. Also, BLM's instream flow rights are used for the same purposes as its base flow claims would be and BLM has not indicated that these rights are insufficient. Plateau therefore recommends that the FRR for those three months also be 0 cfs.

[5] BLM's original period of record ran from 1932 through 1984 but missed 25 intervening calendar years (1941 and 1943 through 1966). Plateau's extended period of record includes those missing years and covers the same period through 1984. It also includes two earlier years (1930 and 1931).

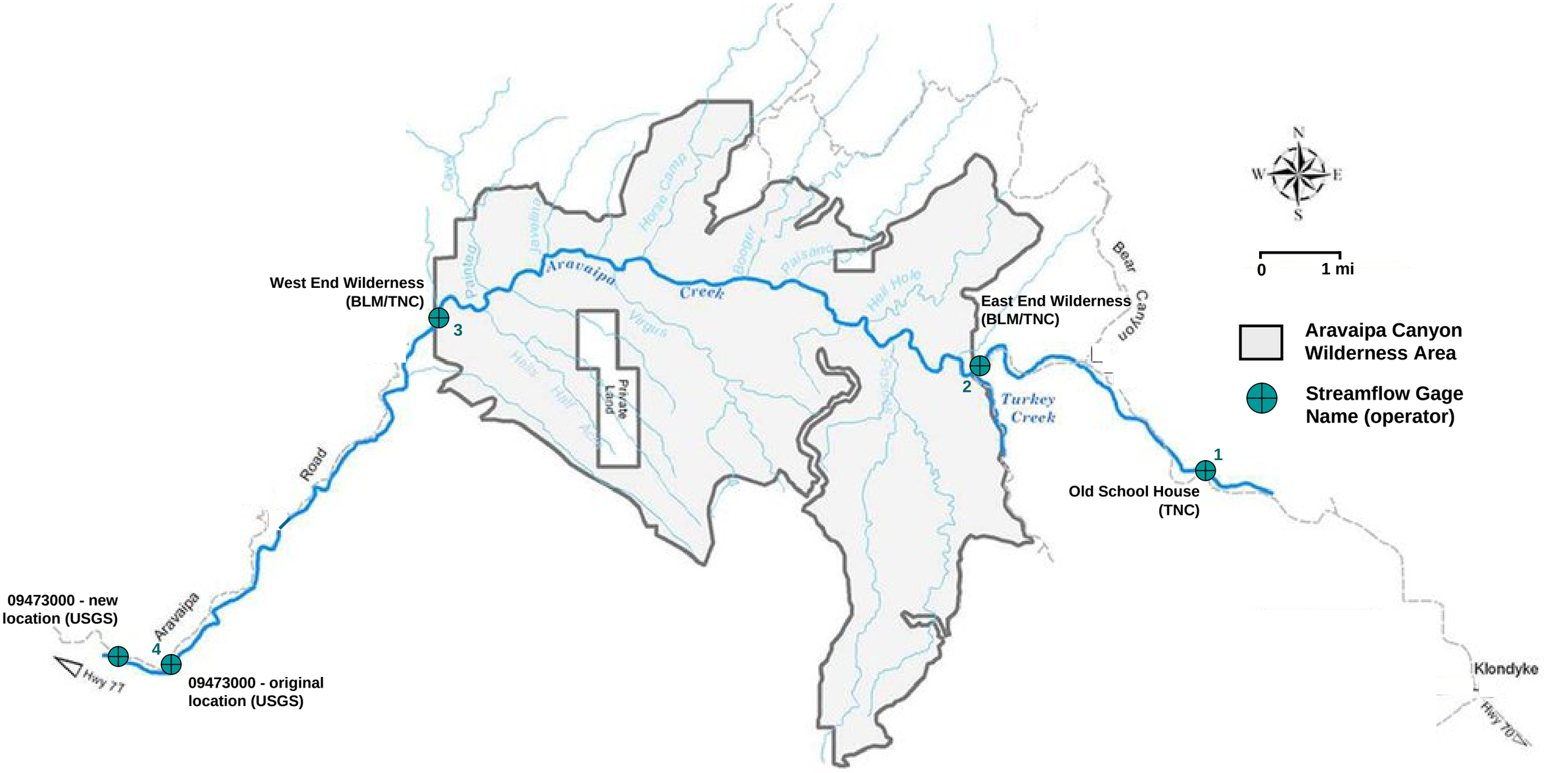
[6] BLM calculates by subtracting its FRR base flow claim from its FRR annual flow claim. Plateau recommends that this be calculated by subtracting BLM's annual instream flow right from Plateau's recommended annual flows at the USGS gage and east and west ACWA boundaries.

[7] The top value reduces to 18,900 and the bottom value reduces to 16,400 if median annual flows are calculated rather than average amounts.

[8] These values would also be reduced if median annual flows are used in place of average amounts.

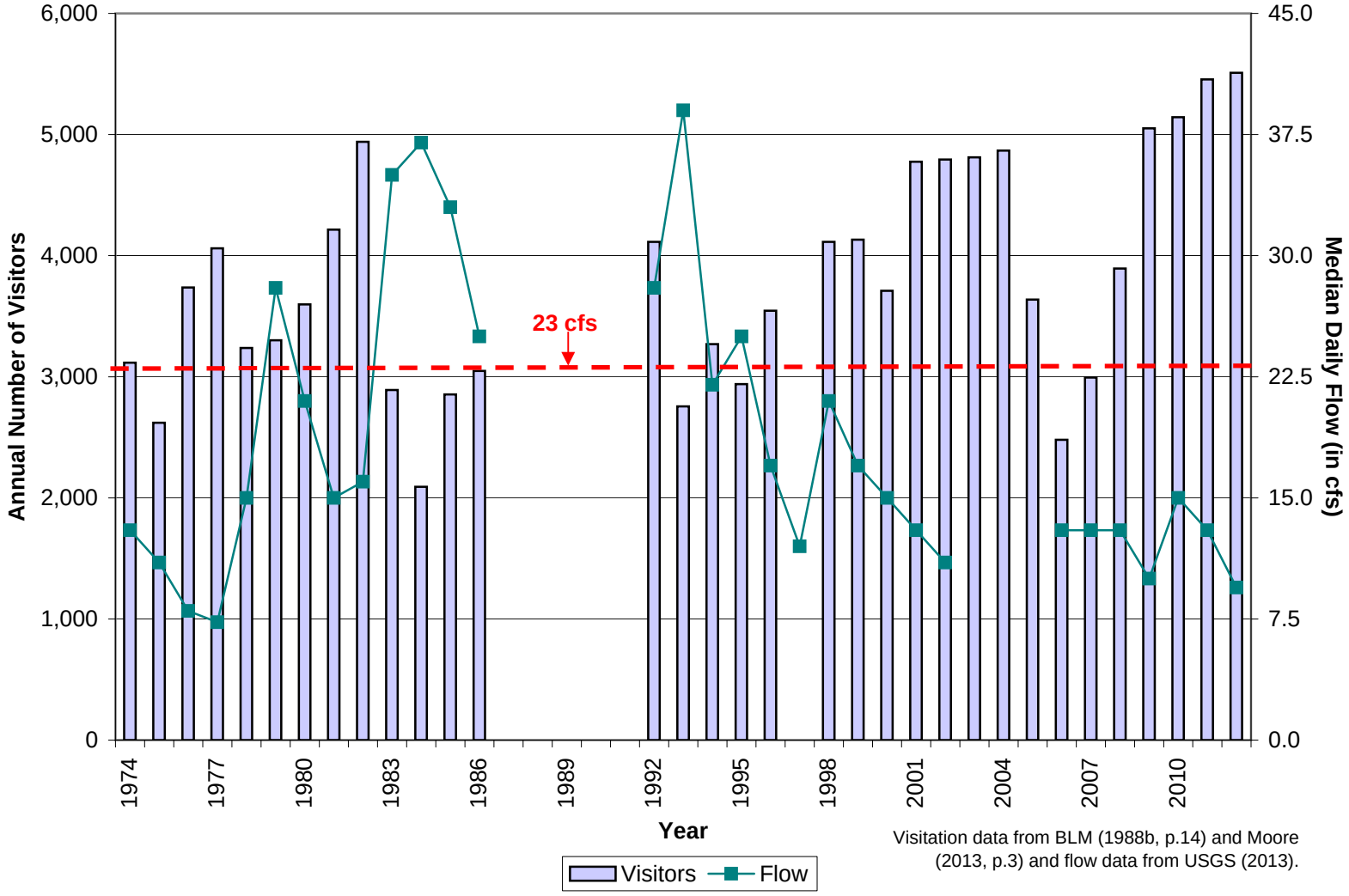
FIGURES

FIGURE 1 – ARAVAIPA CREEK STREAMFLOW GAGES NEAR ARAVAIPA CANYON WILDERNESS AREA



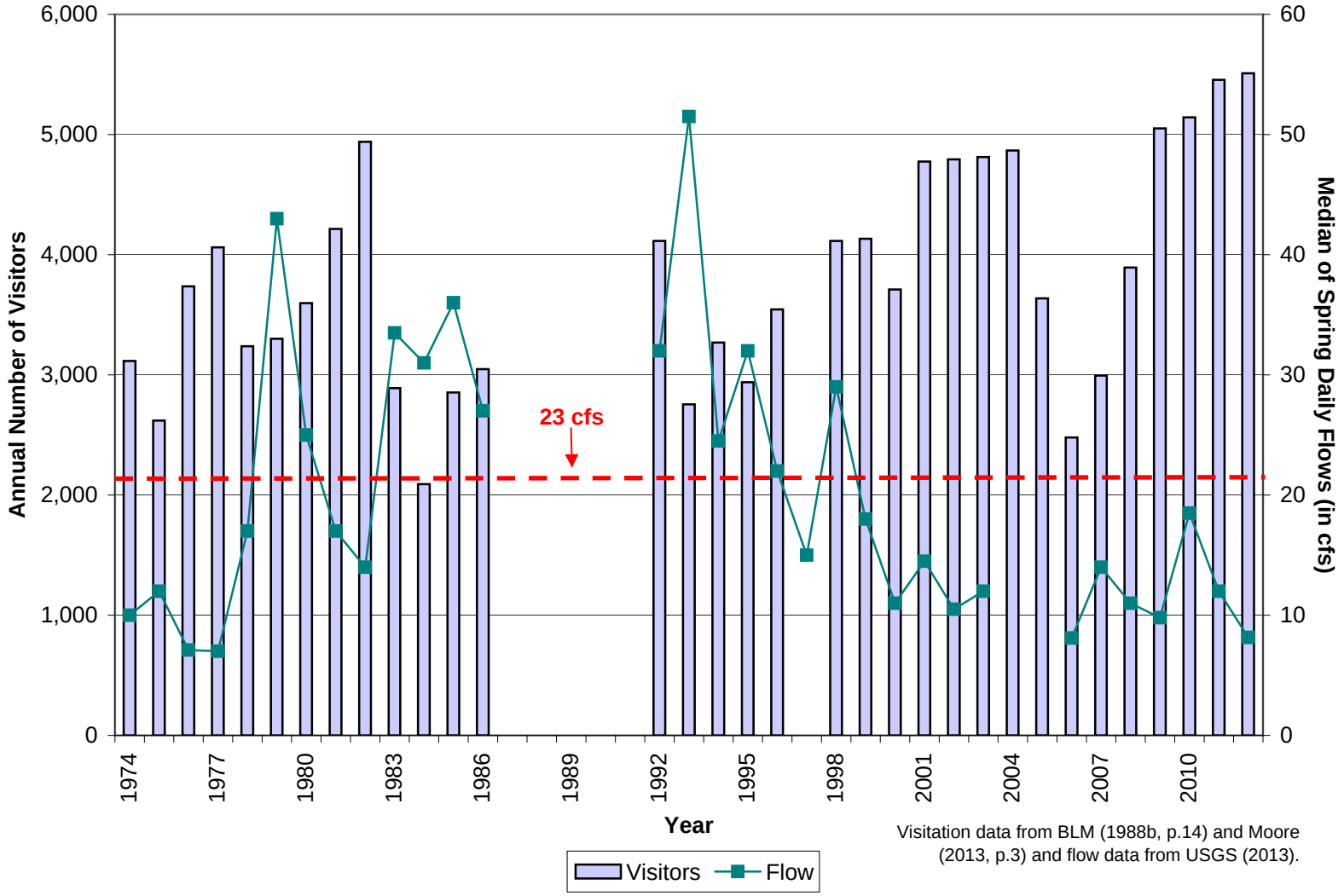
Source: Modified from BLM (2005).

FIGURE 2a - COMPARISON OF ANNUAL ACWA VISITATION TO ANNUAL MEDIAN DAILY STREAMFLOWS IN ARAVAIPA CREEK AT USGS GAGE 09473000



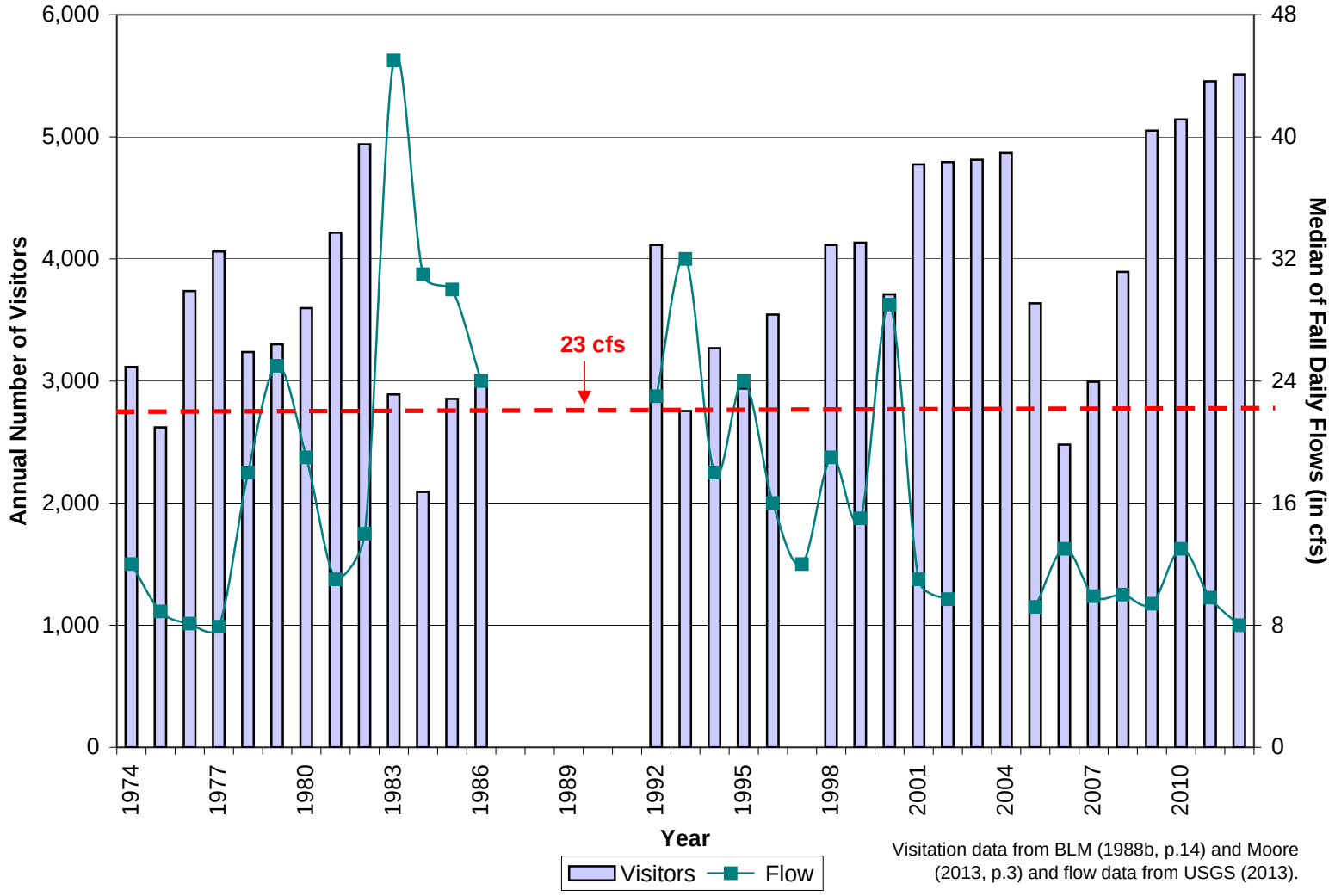
Visitation data from BLM (1988b, p.14) and Moore (2013, p.3) and flow data from USGS (2013).

FIGURE 2b - COMPARISON OF ANNUAL ACWA VISITATION TO SPRING (MARCH-MAY) MEDIAN STREAMFLOWS IN ARAVAIPA CREEK AT USGS GAGE 09473000



Visitation data from BLM (1988b, p.14) and Moore (2013, p.3) and flow data from USGS (2013).

FIGURE 2c - COMPARISON OF ANNUAL ACWA VISITATION TO FALL (OCTOBER-NOVEMBER) MEDIAN STREAMFLOWS IN ARAVAIPA CREEK AT USGS GAGE 09473000



Visitation data from BLM (1988b, p.14) and Moore (2013, p.3) and flow data from USGS (2013).

FIGURE 3 - EXTENSION OF ARAVAIPA CREEK ANNUAL STREAMFLOW RECORD (USGS Gage 09473000)

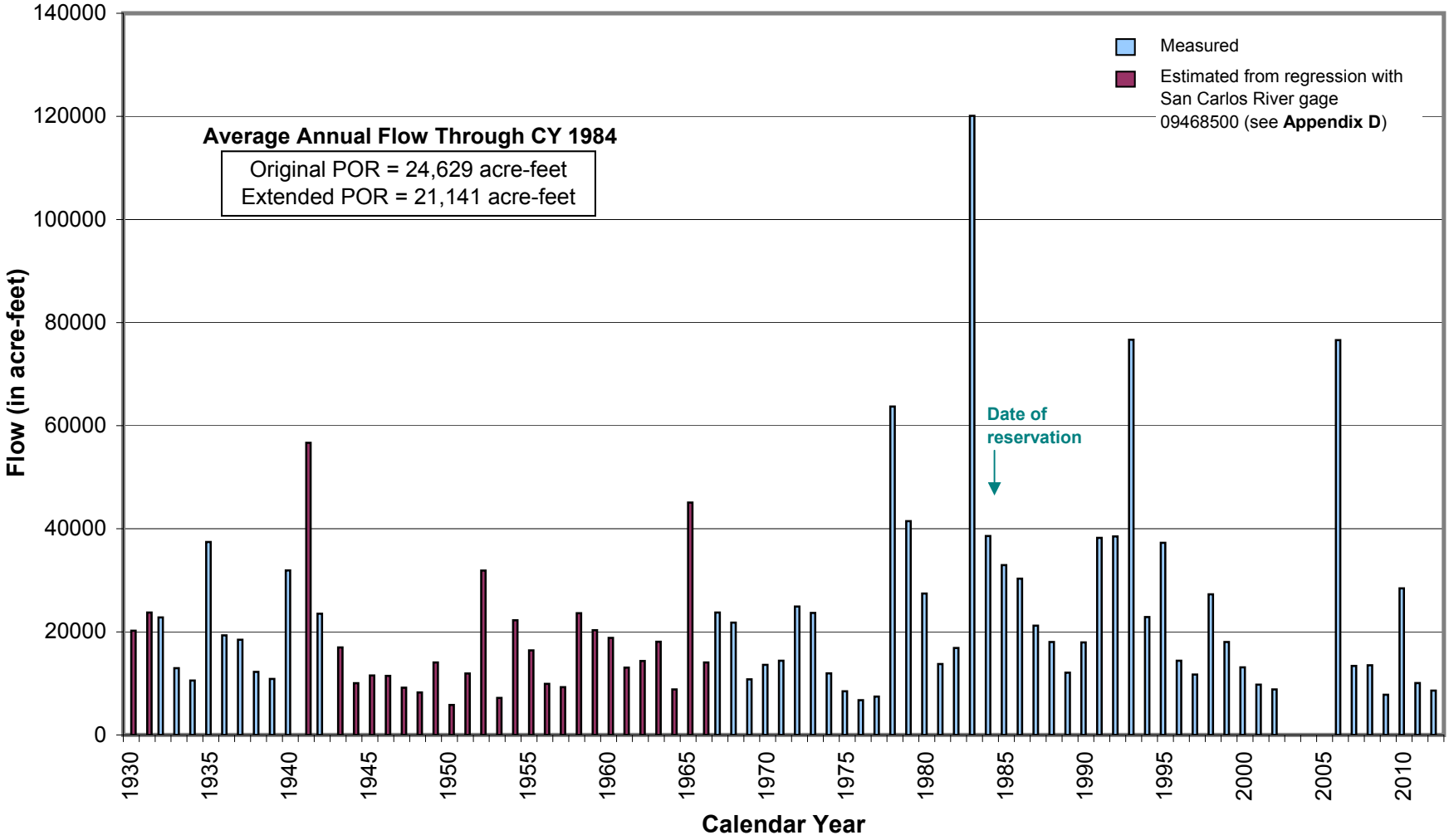
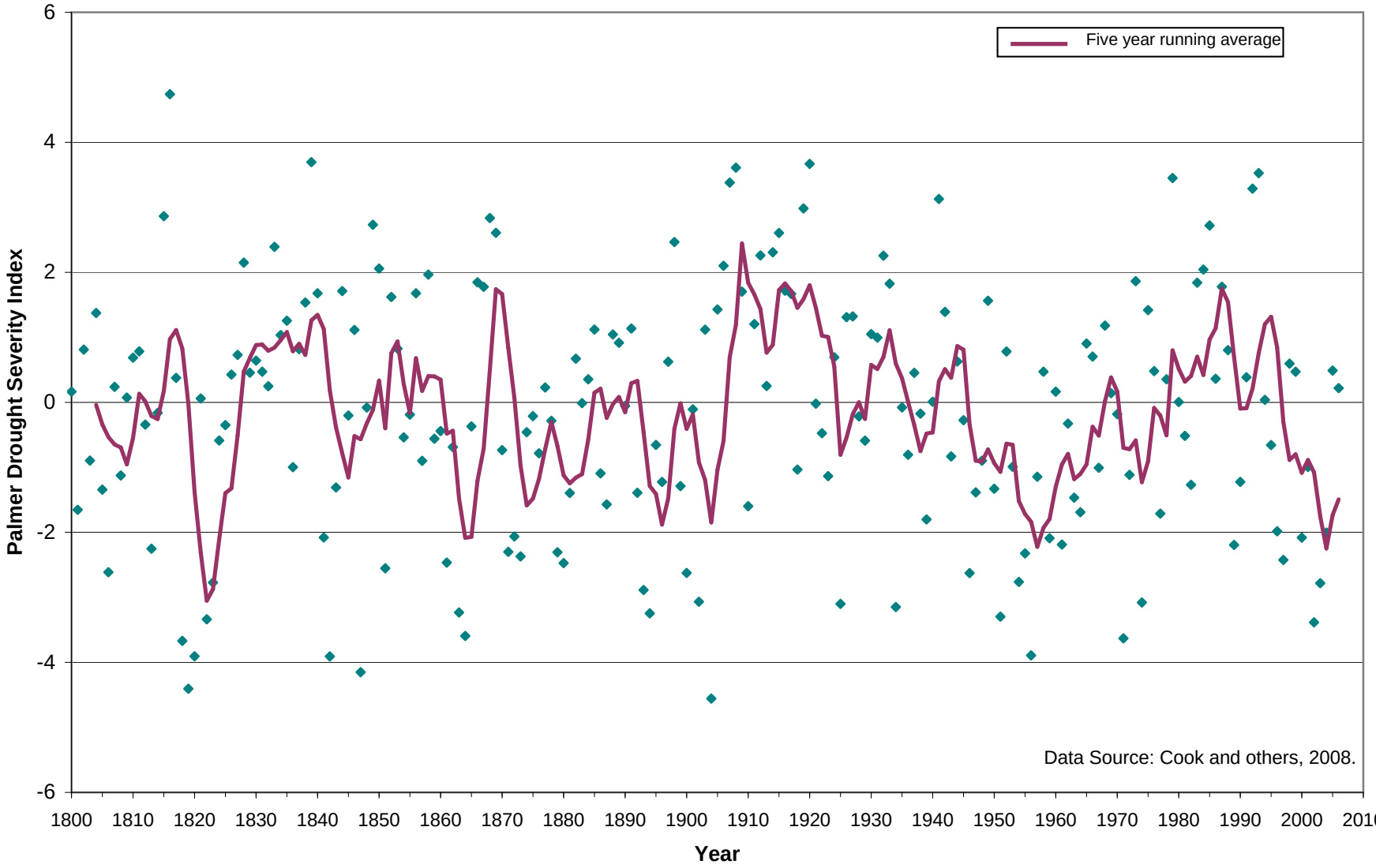


FIGURE 4 - DROUGHT AND WET CYCLES IN SOUTHEASTERN ARIZONA SINCE 1800



APPENDICES

APPENDIX A

ACWA Federal Reserved Water Right Claims

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Assistant Attorney General

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Attorneys for the United States of America

IN THE SUPERIOR COURT OF THE STATE OF ARIZONA
IN AND FOR THE COUNTY OF MARICOPA

IN RE THE GENERAL ADJUDICATION OF ALL RIGHTS TO USE WATER IN THE GILA RIVER SYSTEM AND SOURCE	W1-11-3342 NOTICE OF SUBMISSION OF AMENDED STATEMENT OF CLAIMANT AND REQUEST TO STAY

CONTESTED CASE NAME: *In re Aravaipa Canyon Wilderness Area.*

HSR INVOLVED: San Pedro River Watershed Hydrographic Survey Report.

DESCRIPTIVE SUMMARY: The United States provides notice of submission of an Amended Statement of Claimant for its claim to a federal reserved water right for the Aravaipa Canyon Wilderness Area, and requests that the schedule for amendment of claims to Redfield Canyon Wilderness Area be stayed.

NUMBER OF PAGES: 4

DATE OF FILING: Original mailed to the Clerk of Court on January 3, 2012.

Pursuant to the Case Initiation Order and Designation of Initial Issues for Briefing, dated August 17, 2009, the United States provides notice of its filing of Amended Statement of Claimant No. 39-68704 showing the extent of its claims to federal reserved water rights for the Aravaipa Canyon Wilderness Area. A copy of the amended claim is attached as Exhibit A.

The United States was also ordered to file amendments to Statement of Claimant No. 39-14413 to show the extent of its claims to federal reserved water rights for the Redfield Canyon

Wilderness Area. In response to the United States' previous argument for a reserved right for Aravaipa Canyon Wilderness Area consisting of all the unappropriated water, the Court opined that the amount of water needed to fulfill the purposes of the wilderness area raises genuine issues of material fact, and indicated that principles learned at trial will guide the determination of the quantity reserved. *See* Order Determining the Initial Seven Issues Briefed, Civil No. W1-11-3342, dated November 2, 201, at 18. The question of the quantity of available water and water needed to fulfill the purposes of the wilderness area, therefore, is before the Court in the amended reserved claim to Aravaipa Canyon Wilderness Area. The principles learned in the determination of the reserved quantity in this contested case may assist in quantifying all future claims to water in wilderness areas, including Redfield Canyon Wilderness Area.

Accordingly, the United States respectfully moves for a stay of the order requiring amendment to Statement of Claimant No. 39-14413, the claim to a federal reserved water right for the Redfield Canyon Wilderness Area until after a decision on the quantity of water reserved for Aravaipa Canyon Wilderness Area is reached. The decision in the Aravaipa case may guide the claims, and whether there is a need to amend claims, of future wilderness reserved rights in Arizona including Redfield Canyon Wilderness Area.

RESPECTFULLY SUBMITTED this 3RD day of January 2012.

R. LEE LEININGER
TRIAL ATTORNEY

Certificate of Service

The original and one copy of the foregoing sent via Federal Express this 3RD day of January 2012 to:

Clerk of the Arizona Superior Court
Attn: Water Case
601 W. Jackson St.
Phoenix, AZ 85003

Special Master
Arizona General Stream Adjudication
George A. Schade, Jr.
201 W. Jefferson, CCB 5B
Phoenix AZ 85003-2205

A copy of the foregoing mailed this 3RD day of April 2011 to all parties on the Court-approved W1-11-3342 mailing list dated July 25, 2011.

R. Lee Leininger

For Departmental Use Only

STATEMENT OF CLAIMANT FORM
FOR
OTHER USES[1]
AMENDMENT
SUPERIOR COURT OF MARICOPA COUNTY

1. **Claimant Name:** U.S. Department of the Interior, Bureau of Land Management
   Claimant Address: One North Central Ave., Suite 800 **City** Phoenix
   State: Arizona **Zip Code** 85004-4427 **Telephone** (602) 417-9200

2. **Basis of Claim:**
   - A. ☐ Appropriation Right acquired prior to June 12, 1919. 1974 Water Rights Registration Act Registry No. _____
   - B. ☐ Appropriation Right acquired after June 12, 1919. Application No. _____, Permit No. _____; or Certificate of Water Right No. _____
   - C. ☐ Decreed water right. Principal litigants, court, date and case no. _____
   - D. ☐ Right to withdraw groundwater. Grandfathered Right No. _____
   - E. ☒ Other, describe: Federal Reserved Water Right - Arizona Wilderness Act of 1984, Pub. L. no. 98-406, 98 Stat 1485 (1984) AND Arizona Desert Wilderness Act of 1990, Pub. L. no. 101-628, 104 Stat 4469 (1990)

3. **Claimed Priority Date:** ___/___/___ (month/day/year)
   08 / 28 / 1984 (Instream flow and selected "Point" sources)
   11 / 28 / 1990 (Selected "Point" sources - see Attach. C-1)

4. **Use:**
   - A. ☐ Municipal
   - B. ☐ Commerical or Industrial
   - C. ☐ Mining
   - D. ☐ Stockwatering other than from a stockpond
   - E. ☐ Recreation, Fish & Wildlife
   - F. ☒ Other, describe: _____

5. **Source of Water:**
   - A. ☒ Stream: name Aravaipa Creek, tributary to San Pedro River
   - B. ☒ Spring: name See Attachment C, tributary to Aravaipa Creek
   - C. ☒ Lake or Reservoir: name See Attach. C, tributary to Aravaipa Creek
   - D. ☐ Groundwater.

6. **Legal description of the Point of Diversion:** (attach additional sheet if required) See Attachments A and C
   _____ 1/4, _____ 1/4, _____ 1/4, Section _____, Township _____ N/S, Range _____ E/W

7. **If there are Irrigation, Domestic or Stockpond Uses also supplied from the Point of Diversion, describe:** Not Applicable

8. **Means of Diversion:**
   - A. ☐ Instream pump.
   - B. ☐ Gravity flow into a ditch, canal or pipeline.
   - C. ☐ Well: Arizona Department of Water Resources Well Registration No. 55-_____
   - D. ☒ Other, describe: Instream flow

[1] *See Instructions for explanation of uses in this category*

9. **Means of Conveyance:**

A. ☐ Ditch, canal or pipeline. If the means of conveyance is owned and/or operated by some other entity, please give name and address: _____

B. ☒ Other, describe: Not Applicable

10. **Place of Use, if other than point of diversion:** (attach additional sheet if required)

County Not Applicable (Pinal/Graham)

Legal Subdivision	Section	Township	Range
_____	_____	_____ N/S	_____ E/W
_____	_____	_____ N/S	_____ E/W

11. **Claimed Right:**

A. Maximum Flow Rate: _____ ☐ cubic-feet per second ☐ gallons per minute ☐ Arizona miner's inches

B. Annual Volume of Water Use: 24,799.03 acre-feet (See Attachments B and C)

C. Storage Right: _____ acre-feet

12. Attach photographs, maps or sketches necessary to show the point of diversion, storage resevoir(s) place(s) of use and means of conveyance. (See Attachments A and C)

13. It may be necessary for a representative from the Department of Water Resources to inspect the diversion, conveyance and place of use. Your signature following will grant permission to enter your property for the purpose of inspection: Signature of Claimant William E. Wells

14. Should it be necessary for a representative of the Department to contact you as the claimant or your representative, are there any special instructions regarding time of day or address to aid in locating the specified person? Normal business hours

15. Additional comments: The original Statement of Claimant (#39-68704) for a federal reserved water right within the Aravaipa Canyon Wilderness Area was filed in March 1991 and amended in October 1994 and February 1995.

(attach additional sheet if required)

16. Mail form(s) to: AZ DEPT OF WATER RESOURCES
ADJUDICATIONS
PO BOX 36020
PHOENIX AZ 85067-6020

17. **Notarized Statement:**

William E Wells

I (We), U.S. Department of the Interior, Bureau of Land Management the claimant(s) named in this claim, do hereby certify under penalty of perjury, that the information contained [illegible] to the best of my (our) knowledge and belief true, correct and complete.

CHELSEA DEBEE
Notary Public - Arizona
Pima County
My Comm. Expires Sep 18, 2015
(seal)

expires Sep 18, 2015
My Commission Expires

_____
_____
_____
Notary Public

or, _____
Authorized Personnel of the Department of Water Resources

List of Attachments

FEDERAL RESERVED WATER RIGHT - ARAVAIPA CANYON WILDERNESS AREA (ACWA)
STATEMENT OF CLAIMANT NO. 39 - 68704

ATTACHMENT A

Places of Use

ACWA geographic boundary as defined in:

- Arizona Wilderness Act of 1984, Pub. L. no. 98-406, 98 Stat 1485 (1984) and;
- Arizona Desert Wilderness Act of 1990, Pub. L. no. 101-628, 104 Stat 4469 (1990).

Map A also includes the location of the USGS stream gauge station.

ATTACHMENT B

Surface Water Flows

Aravaipa Creek instream flow claim within the ACWA boundary with discussion.

ATTACHMENT C

"Point" Water Sources

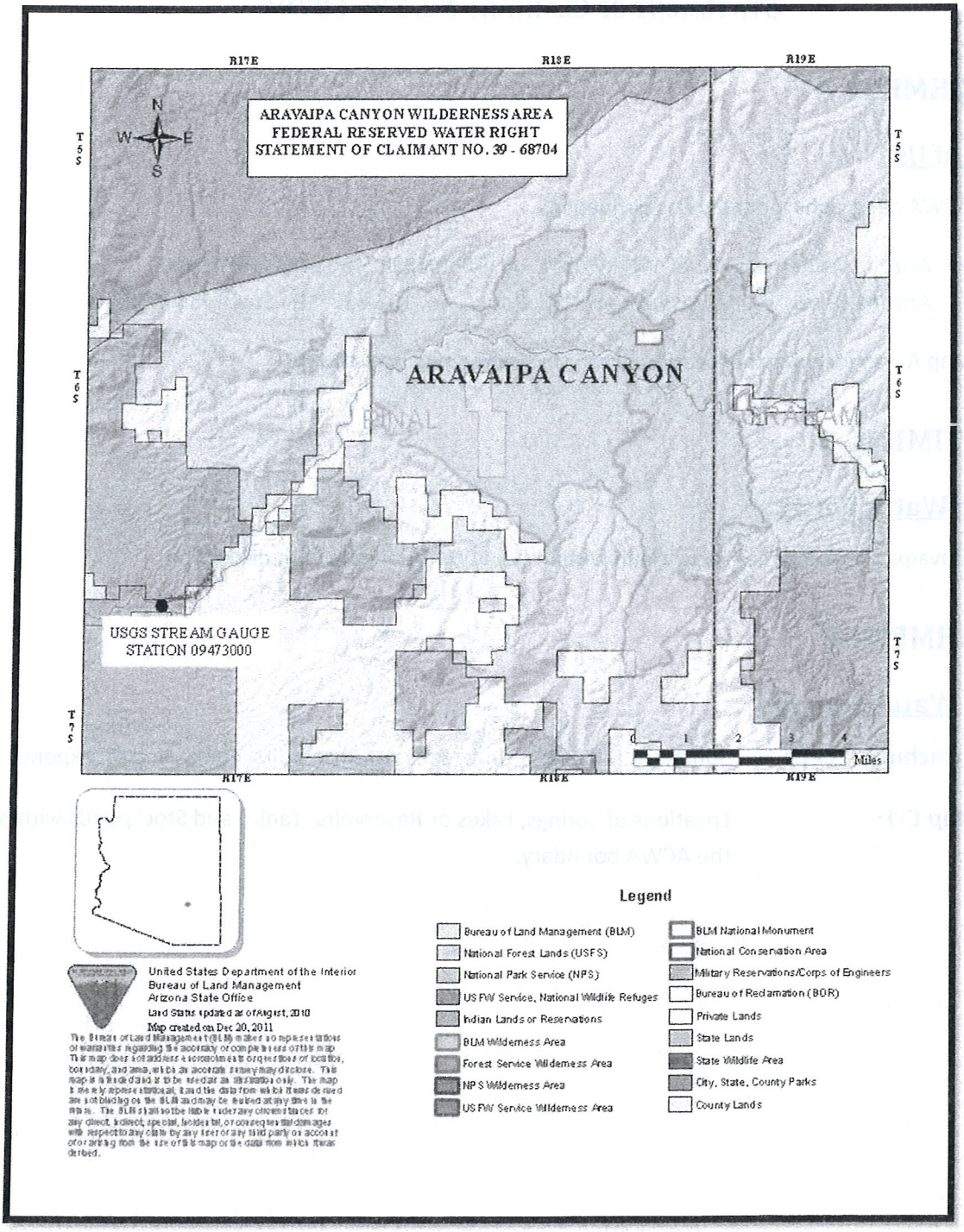
Attachment C-1: Summary Table of Springs, Lakes or Reservoirs, Tanks, and Stockponds.

Map C-1: Locations of Springs, Lakes or Reservoirs, Tanks, and Stockponds within the ACWA boundary.

ATTACHMENT A

FEDERAL RESERVED WATER RIGHT – ARAVAIPA CANYON WILDERNESS AREA (ACWA)

STATEMENT OF CLAIMANT FILE NO. 39 – 68704



December 2011

ATTACHMENT B

FEDERAL RESERVED WATER RIGHT – ARAVAIPA CANYON WILDERNESS AREA (ACWA)

STATEMENT OF CLAIMANT FILE NO. 39 - 68704

1. Required annual total volume: **24,600 acre-feet**. Date Claimed is Aug. 28, 1984.

Aravaipa Creek – Aravaipa Canyon Wilderness Area		
	Base Flow (cubic feet per second)	Volume (Acre-Feet)
January	16	982
February	18	998
March	18	1,105
April	13	772
May	10	614
June	6	356
July	10	614
August	14	859
September	12	713
October	11	675
November	12	713
December	17	1,043
Total Base Flow		9,444
Un-impounded Flood Flow		15,156
Total Claim		**24,600**

2. Estimated required flood flows(cfs)

Flood Flow Return Period	Estimated Flow (cfs)
2 Year	4,540
10 Year	15,600
25 Year	26,300
50 Year	37,000
100 Year	50,700

Discussion

Stream flow claims for Aravaipa Creek are based on complete year records between 1932 through 1984 at the USGS stream gauge located on Aravaipa Creek near Mammoth, AZ (09473000). Twenty-Eight complete year records existed during this period and included the following years: 1932-1940, 1942, and 1967-1984. The beginning of the analysis was set at 1932 to coincide with the installation and operation of the stream gauge. The end of the analysis was set at 1984 to coincide with the establishment of the Aravaipa Canyon Wilderness Area. Base flows for each month represent the median of all daily means for the indicated month in the period of record. Total volume claimed represents the mean of all annual volumes for the period of record. The difference between the sum of the monthly base flow claim and the total volume claimed represents the un-impounded natural runoff from seasonal storm events.

ATTACHMENT C

FEDERAL RESERVED WATER RIGHT – ARAVAIPA CANYON WILDERNESS AREA (ACWA)

STATEMENT OF CLAIMANT FILE NO. 39 – 68704

Point Sources

The Bureau of Land Management (BLM) claims discrete or "point" water sources with the ACWA. These sources may include:

- Springs and seeps
- Ponds and small lakes
- Any other naturally occurring waters (e.g., seasonal Cienegas, small riverside oxbow lakes, undiscovered seeps, springs, ponds, etc.) with the ACWA

Discussion

The amount of water claimed for springs and seeps is the measured flow and corresponding volume per annum. The amount of water claimed for ponds and small lakes is the maximum capacity.

Attachment C-1 identifies in table format each "point" source, its location, and amount claimed.

Map C-1 shows the approximate locations of the "point" sources within the geographic boundary of the ACWA which are included in this amendment.

ATTACHMENT C-1

FEDERAL RESERVED WATER RIGHT – ARAVAIPA CANYON WILDERNESS AREA (ACWA)

FOURTH AMENDMENT – STATEMENT OF CLAIMANT FILE NO. 39 – 68704

Point Source	Location	Date Claimed	Quantity (acre-feet)
	SPRINGS		
North Booger Spring	NW SE Sec 10, T6S, R18E	Nov. 28, 1990	0.80
East Booger Spring	SW SE Sec 10, T6S, R18E	Nov. 28, 1990	8.10
Natural Boundary Spring	SW SW Sec 7, T6S, R19E	Nov. 28, 1990	15.20
Hanging Spring	NW NW Sec 18, T6S, R19E	Nov. 28, 1990	80.00
Saltuna Spring	NW SE Sec 13, T6S, R18E	Aug. 28, 1984	58.00
Goat Spring	NW SW Sec 25, T6S, R18E	Aug. 28, 1984	1.61
Purgatory Spring	NW NW Sec 13, T6S, R18E	Aug. 28, 1984	0.80
Stone Cabin Spring	NW SW Sec 27, T6S, R18E	Nov. 28, 1990	0.12
Lower Stone Cabin Spring	NW NW Sec 27, T6S, R18E	Nov. 28, 1990	0.17
Lupie Seep	NW SW Sec 27, T6S, R18E	Nov. 28, 1990	0.10
Buggar Spring	NW SE Sec 8, T6S, R18E	Aug. 28, 1984	9.05
Janette Spring	SW NE Sec 7, T6S, R19E	Nov. 28, 1990	8.06
Rock Tub Spring	NW NE Sec 7, T6S, R19E	Nov. 28, 1990	0.80
McRae Spring	NE NE Sec 35, T6S, R18E	Nov. 28, 1990	0.13
SUBTOTAL			**182.94**

ATTACHMENT C-1

FEDERAL RESERVED WATER RIGHT – ARAVAIPA CANYON WILDERNESS AREA (ACWA)

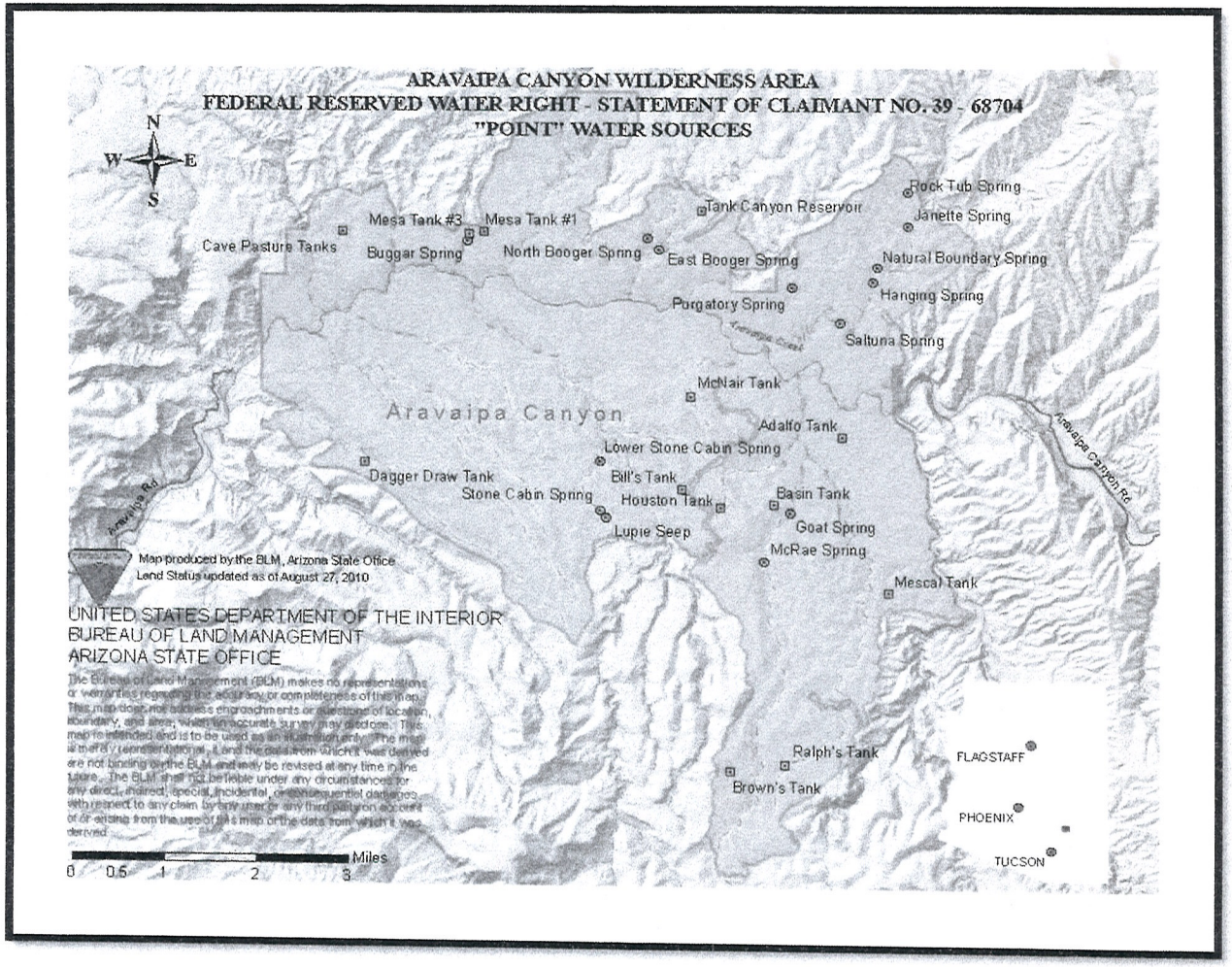
FOURTH AMENDMENT – STATEMENT OF CLAIMANT FILE NO. 39 – 68704

Point Source	Location	Date Claimed	Quantity (acre-feet)
		PONDS	
Cave Pasture Tanks	NE SW Sec 7, T6S, R18E	Nov. 28, 1990	0.09
Mesa Tank #1	SE NE Sec 8, T6S, R18E	Aug. 28, 1984	1.40
Basin Tank	NE SE Sec 26, T6S, R18E	Nov. 28, 1990	0.06
Houston Tank	NE SW Sec 26, T6S, R18E	Nov. 28, 1990	2.38
Bill's Tank	SE NE Sec 27, T6S, R18E	Nov. 28, 1990	0.50
Mescal Tank	NW SW Sec 31, T6S, R19E	Nov. 28, 1990	0.03
Brown's Tank	SE NW Sec 11, T7S, R18E	Nov. 28, 1990	2.22
Ralph's Tank	SW NW Sec 12, T7S, R18E	Nov. 28, 1990	2.13
McNair Tank	SW NW Sec 23, T6S, R18E	Nov. 28, 1990	3.08
Mesa Tank #3	NE SE Sec 8, T6S, R18E	Aug. 28, 1984	0.35
Dagger Draw Tank	NE NW Sec 30, T 6S, R18E	Nov. 28, 1990	3.25
Adalfo Tank	SW SE Sec 24, T6S, R18	Aug. 28, 1984	0.33
Tank Canyon Reservoir	SW NW Sec 11, T6S, R18E	Nov. 28, 1990	0.27
SUBTOTAL			**16.09**
GRAND TOTAL			**199.03**

MAP C-1

FEDERAL RESERVED WATER RIGHT – ARAVAIPA CANYON WILDERNESS AREA (ACWA)

FOURTH AMENDMENT – STATEMENT OF CLAIMANT FILE NO. 39 – 68704



December 2011

APPENDIX B

PeakFQWin Program Output Reports

1

```
  Program PeakFq           U. S. GEOLOGICAL SURVEY             Seq.000.000
  Ver. 5.2            Annual peak flow frequency analysis      Run Date / Time
  11/01/2007          following Bulletin 17-B Guidelines       05/08/2013 10:08

                         --- PROCESSING OPTIONS ---

                      Plot option         = Graphics & Printer
                      Basin char output   = WATSTORE
                      Print option        = Yes
                      Debug print         = No
                      Input peaks listing = Long
                      Input peaks format  = WATSTORE peak file

                      Input files used:
                         peaks (ascii)  - C:\PROJECTS\ARAVAIPA\FLOW RESEARCH\FLOOD FLOW
ANALYSIS\USGS 9473000 CALCS\947300
                         specifications - PKFQWPSF.TMP

                      Output file(s):
                         main - C:\PROJECTS\ARAVAIPA\FLOW RESEARCH\FLOOD FLOW ANALYSIS\USGS 9473000
CALCS\947300
                         bcd  - 9473000 PARTIAL.BCD
```

1

```
  Program PeakFq           U. S. GEOLOGICAL SURVEY             Seq.001.001
  Ver. 5.2            Annual peak flow frequency analysis      Run Date / Time
  11/01/2007          following Bulletin 17-B Guidelines       05/08/2013 10:08

              Station - 09473000  ARAVAIPA CREEK NEAR MAMMOTH, AZ.


                   I N P U T   D A T A   S U M M A R Y

                Number of peaks in record            =       30
                Peaks not used in analysis           =        0
                Systematic peaks in analysis         =       30
                Historic peaks in analysis           =        0
                Years of historic record             =        0
                Generalized skew                     =   -0.200
                     Standard error                  =    0.550
                     Mean Square error               =    0.303
                Skew option                          =   WEIGHTED
                Gage base discharge                  =      0.0
                User supplied high outlier threshold =   --
                User supplied low outlier criterion  =   --
                Plotting position parameter          =     0.00
```

```
  *********  NOTICE  --  Preliminary machine computations.        *********
  *********  User responsible for assessment and interpretation.  *********

    WCF134I-NO SYSTEMATIC PEAKS WERE BELOW GAGE BASE.                   0.0
    WCF195I-NO LOW OUTLIERS WERE DETECTED BELOW CRITERION.            451.3
    WCF163I-NO HIGH OUTLIERS OR HISTORIC PEAKS EXCEEDED HHBASE.     35873.8
1


  Program PeakFq           U. S. GEOLOGICAL SURVEY             Seq.001.002
  Ver. 5.2              Annual peak flow frequency analysis    Run Date / Time
  11/01/2007            following Bulletin 17-B Guidelines     05/08/2013 10:08

              Station - 09473000  ARAVAIPA CREEK NEAR MAMMOTH, AZ.


           ANNUAL FREQUENCY CURVE PARAMETERS -- LOG-PEARSON TYPE III

                        FLOOD BASE                  LOGARITHMIC
                  ----------------------  -------------------------------
                                EXCEEDANCE                   STANDARD
                   DISCHARGE  PROBABILITY      MEAN         DEVIATION      SKEW
                  ---------------------------------------------------------
 SYSTEMATIC RECORD       0.0      1.0000      3.6046         0.3707       0.332
 BULL.17B ESTIMATE       0.0      1.0000      3.6046         0.3707       0.123


     ANNUAL FREQUENCY CURVE -- DISCHARGES AT SELECTED EXCEEDANCE PROBABILITIES

       ANNUAL                                    'EXPECTED   95-PCT CONFIDENCE LIMITS
    EXCEEDANCE      BULL.17B     SYSTEMATIC PROBABILITY'  FOR BULL. 17B ESTIMATES
    PROBABILITY     ESTIMATE       RECORD      ESTIMATE        LOWER         UPPER

        0.9950         492.8         582.1         414.8         258.2         765.7
        0.9900         597.0         681.3         521.0         327.9         901.7
        0.9500        1019.0        1076.0         954.0         633.9        1431.0
        0.9000        1364.0        1395.0        1308.0         902.9        1852.0
        0.8000        1952.0        1942.0        1910.0        1383.0        2568.0
        0.6667        2747.0        2686.0        2721.0        2045.0        3554.0
        0.5000        3953.0        3838.0        3953.0        3038.0        5136.0
        0.4292        4606.0        4473.0        4623.0        3559.0        6040.0
        0.2000        8207.0        8113.0        8401.0        6244.0       11570.0
        0.1000       12140.0       12330.0       12720.0        8918.0       18420.0
        0.0400       18580.0       19680.0       20260.0       12960.0       30940.0
        0.0200       24560.0       26930.0       27780.0       16490.0       43670.0
        0.0100       31660.0       35990.0       37390.0       20490.0       59880.0
        0.0050       40040.0       47250.0       49650.0       25010.0       80270.0
        0.0020       53370.0       66280.0       71260.0       31880.0      115100.0
```

1

Program PeakFq U. S. GEOLOGICAL SURVEY Seq.001.003
Ver. 5.2 Annual peak flow frequency analysis Run Date / Time
11/01/2007 following Bulletin 17-B Guidelines 05/08/2013 10:08

Station - 09473000 ARAVAIPA CREEK NEAR MAMMOTH, AZ.

I N P U T D A T A L I S T I N G

WATER YEAR	DISCHARGE	CODES	WATER YEAR	DISCHARGE	CODES
1933	9340.0		1971	1780.0	
1934	3100.0		1972	1830.0	
1935	10200.0		1973	8200.0	
1936	6500.0		1974	2100.0	
1937	3380.0		1975	836.0	
1938	3600.0		1976	1120.0	
1939	6450.0		1977	2560.0	
1940	5480.0		1978	5100.0	
1941	9600.0		1979	16200.0	
1965	4480.0		1980	2460.0	
1966	6340.0		1981	2460.0	
1967	2340.0		1982	1620.0	
1968	15300.0		1983	3920.0	
1969	1800.0		1984	30000.0	
1970	5560.0		1985	1330.0	

Explanation of peak discharge qualification codes

PeakFQ CODE	NWIS CODE	DEFINITION
D	3	Dam failure, non-recurrent flow anomaly
G	8	Discharge greater than stated value
X	3+8	Both of the above
L	4	Discharge less than stated value
K	6 OR C	Known effect of regulation or urbanization
H	7	Historic peak

\- Minus-flagged discharge -- Not used in computation
-8888.0 -- No discharge value given
\- Minus-flagged water year -- Historic peak used in computation

1

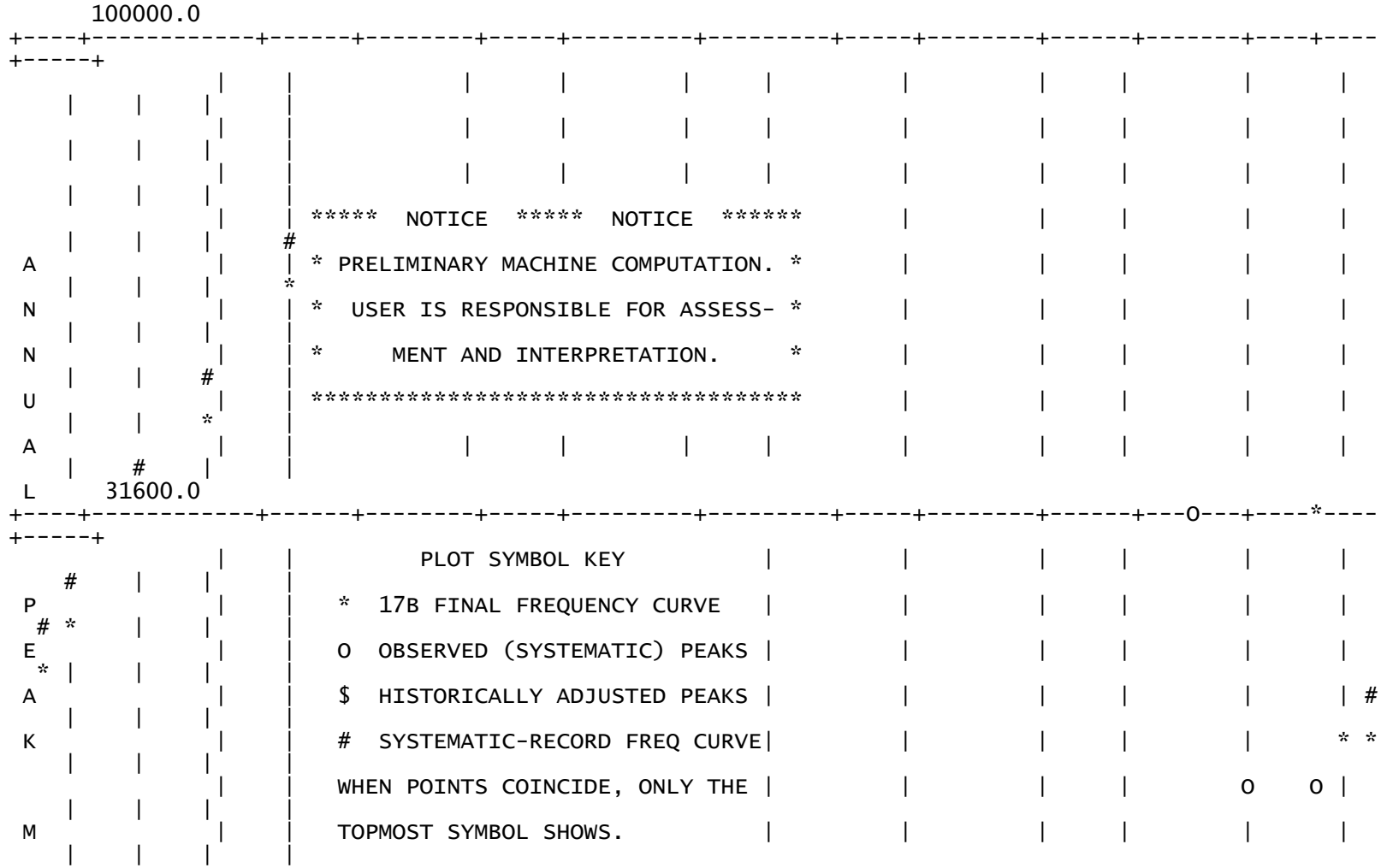
Program PeakFq U. S. GEOLOGICAL SURVEY Seq.001.004
Ver. 5.2 Annual peak flow frequency analysis Run Date / Time
11/01/2007 following Bulletin 17-B Guidelines 05/08/2013 10:08

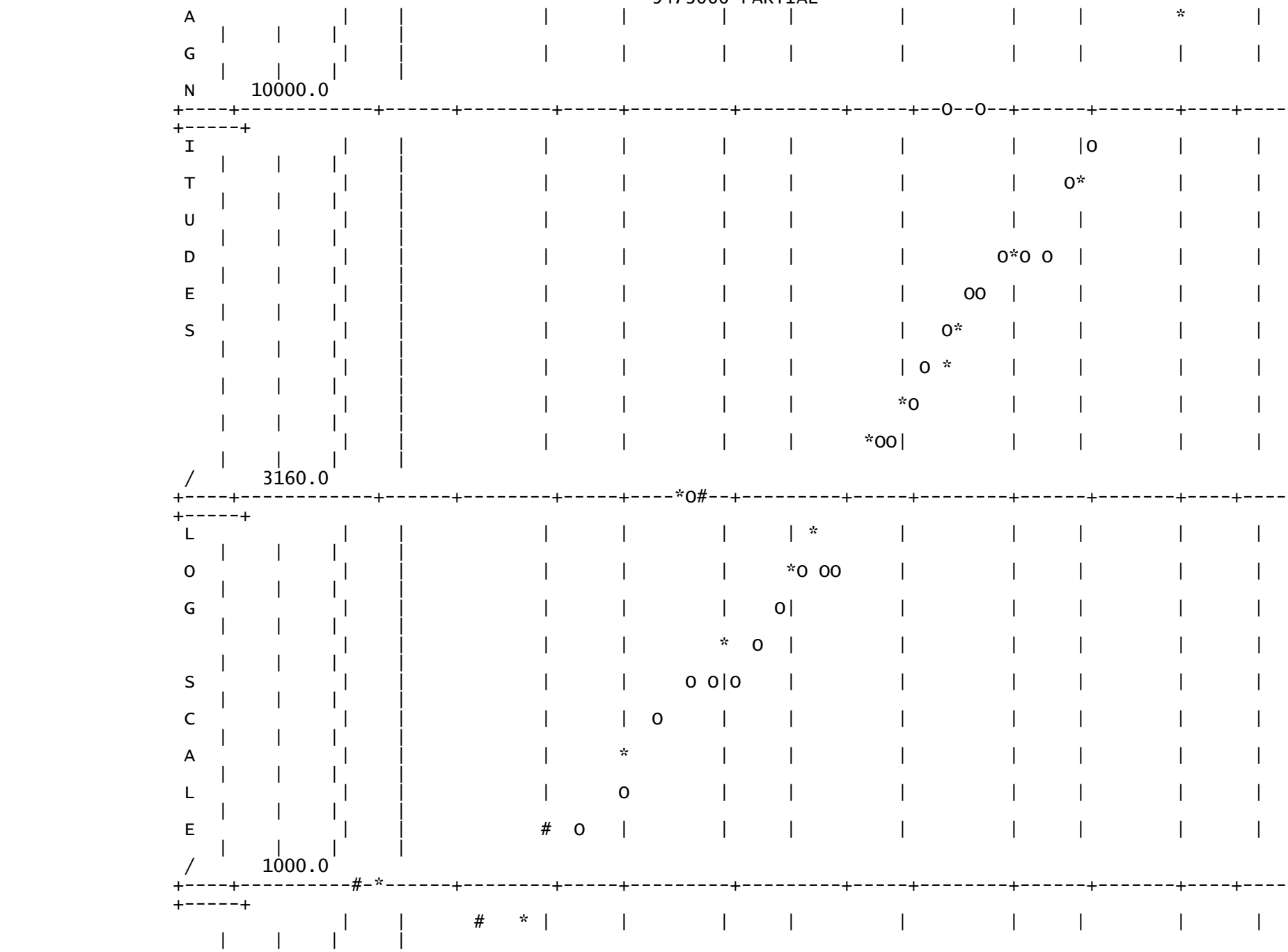
Station - 09473000 ARAVAIPA CREEK NEAR MAMMOTH, AZ.

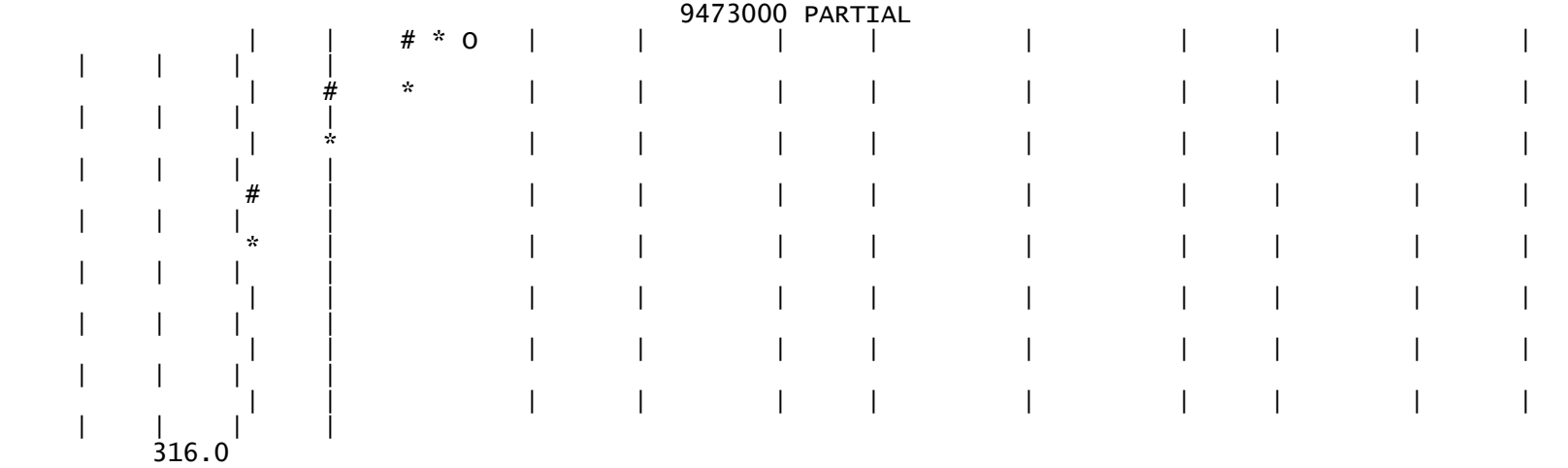
EMPIRICAL FREQUENCY CURVES -- WEIBULL PLOTTING POSITIONS

WATER YEAR	RANKED DISCHARGE	SYSTEMATIC RECORD	BULL.17B ESTIMATE
1984	30000.0	0.0323	0.0323
1979	16200.0	0.0645	0.0645
1968	15300.0	0.0968	0.0968
1935	10200.0	0.1290	0.1290
1941	9600.0	0.1613	0.1613
1933	9340.0	0.1935	0.1935
1973	8200.0	0.2258	0.2258
1936	6500.0	0.2581	0.2581
1939	6450.0	0.2903	0.2903
1966	6340.0	0.3226	0.3226
1970	5560.0	0.3548	0.3548
1940	5480.0	0.3871	0.3871
1978	5100.0	0.4194	0.4194
1965	4480.0	0.4516	0.4516
1983	3920.0	0.4839	0.4839
1938	3600.0	0.5161	0.5161
1937	3380.0	0.5484	0.5484
1934	3100.0	0.5806	0.5806
1977	2560.0	0.6129	0.6129
1980	2460.0	0.6452	0.6452
1981	2460.0	0.6774	0.6774
1967	2340.0	0.7097	0.7097
1974	2100.0	0.7419	0.7419
1972	1830.0	0.7742	0.7742
1969	1800.0	0.8065	0.8065
1971	1780.0	0.8387	0.8387
1982	1620.0	0.8710	0.8710
1985	1330.0	0.9032	0.9032
1976	1120.0	0.9355	0.9355
1975	836.0	0.9677	0.9677

Station - 09473000 ARAVAIPA CREEK NEAR MAMMOTH, AZ.




A
G
N
10000.0
I
T
U
D
E
S
3160.0
L
O
G
S
C
A
L
E
1000.0



1

End PeakFQ analysis.
Stations processed : 1
Number of errors : 0
Stations skipped : 0
Station years : 30

Data records may have been ignored for the stations listed below.
(Card type must be Y, Z, N, H, I, 2, 3, 4, or *.)
(2, 4, and * records are ignored.)

For the station below, the following records were ignored:

FINISHED PROCESSING STATION: 09473000 USGS ARAVAIPA CREEK NEAR MAMMOTH,

For the station below, the following records were ignored:

FINISHED PROCESSING STATION:

1

Program PeakFq U. S. GEOLOGICAL SURVEY Seq.000.000
Ver. 5.2 Annual peak flow frequency analysis Run Date / Time
11/01/2007 following Bulletin 17-B Guidelines 05/08/2013 09:52

--- PROCESSING OPTIONS ---

Plot option = Graphics & Printer
Basin char output = TAB-SEPARATED
Print option = Yes
Debug print = No
Input peaks listing = Long
Input peaks format = WATSTORE peak file

Input files used:
peaks (ascii) - C:\PROJECTS\ARAVAIPA\FLOW RESEARCH\FLOOD FLOW ANALYSIS\USGS 9473000 CALCS\094730
specifications - PKFQWPSF.TMP

Output file(s):
main - C:\PROJECTS\ARAVAIPA\FLOW RESEARCH\FLOOD FLOW ANALYSIS\USGS 9473000 CALCS\094730
bcd - 09473000 FULL PERIOD OF RECORD.BCD

1

Program PeakFq U. S. GEOLOGICAL SURVEY Seq.001.001
Ver. 5.2 Annual peak flow frequency analysis Run Date / Time
11/01/2007 following Bulletin 17-B Guidelines 05/08/2013 09:52

Station - 09473000 ARAVAIPA CREEK NEAR MAMMOTH, AZ.

I N P U T D A T A S U M M A R Y

Number of peaks in record	= 62
Peaks not used in analysis	= 0
Systematic peaks in analysis	= 62
Historic peaks in analysis	= 0
Years of historic record	= 0
Generalized skew	= -0.200
Standard error	= 0.550
Mean Square error	= 0.303
Skew option	= WEIGHTED
Gage base discharge	= 0.0
User supplied high outlier threshold	= --

User supplied low outlier criterion = --
Plotting position parameter = 0.00

********* NOTICE -- Preliminary machine computations. *********
********* User responsible for assessment and interpretation. *********

WCF134I-NO SYSTEMATIC PEAKS WERE BELOW GAGE BASE. 0.0
WCF195I-NO LOW OUTLIERS WERE DETECTED BELOW CRITERION. 335.0
WCF163I-NO HIGH OUTLIERS OR HISTORIC PEAKS EXCEEDED HHBASE. 45507.3

1

Program PeakFq U. S. GEOLOGICAL SURVEY Seq.001.002
Ver. 5.2 Annual peak flow frequency analysis Run Date / Time
11/01/2007 following Bulletin 17-B Guidelines 05/08/2013 09:52

Station - 09473000 ARAVAIPA CREEK NEAR MAMMOTH, AZ.

ANNUAL FREQUENCY CURVE PARAMETERS -- LOG-PEARSON TYPE III

	FLOOD BASE		LOGARITHMIC		
	DISCHARGE	EXCEEDANCE PROBABILITY	MEAN	STANDARD DEVIATION	SKEW
SYSTEMATIC RECORD	0.0	1.0000	3.5916	0.3743	0.279
BULL.17B ESTIMATE	0.0	1.0000	3.5916	0.3743	0.159

ANNUAL FREQUENCY CURVE -- DISCHARGES AT SELECTED EXCEEDANCE PROBABILITIES

ANNUAL EXCEEDANCE PROBABILITY	BULL.17B ESTIMATE	SYSTEMATIC RECORD	'EXPECTED PROBABILITY' ESTIMATE	95-PCT CONFIDENCE LIMITS FOR BULL. 17B ESTIMATES LOWER	UPPER
0.9950	482.3	531.4	446.1	318.6	663.8
0.9900	581.7	628.3	546.7	395.6	784.7
0.9500	984.5	1016.0	954.7	722.7	1260.0
0.9000	1314.0	1332.0	1289.0	1002.0	1640.0
0.8000	1879.0	1873.0	1860.0	1493.0	2288.0
0.6667	2645.0	2611.0	2634.0	2165.0	3175.0
0.5000	3816.0	3751.0	3816.0	3179.0	4577.0
0.4292	4453.0	4378.0	4460.0	3719.0	5365.0
0.2000	8005.0	7952.0	8097.0	6580.0	10060.0

0.1000	11950.0	12050.0	12220.0	9549.0	15720.0
0.0400	18490.0	19120.0	19280.0	14210.0	25830.0
0.0200	24660.0	26010.0	26170.0	18400.0	35930.0
0.0100	32060.0	34550.0	34730.0	23260.0	48630.0
0.0050	40900.0	45040.0	45340.0	28870.0	64440.0
0.0020	55150.0	62570.0	63290.0	37620.0	91160.0

1

Program PeakFq
Ver. 5.2
11/01/2007

U. S. GEOLOGICAL SURVEY
Annual peak flow frequency analysis
following Bulletin 17-B Guidelines

Seq.001.003
Run Date / Time
05/08/2013 09:52

Station - 09473000 ARAVAIPA CREEK NEAR MAMMOTH, AZ.

I N P U T D A T A L I S T I N G

WATER YEAR	DISCHARGE	CODES	WATER YEAR	DISCHARGE	CODES
1919	20000.0		1982	1620.0	
1920	7400.0		1983	3920.0	
1921	12600.0		1984	30000.0	
1931	4700.0		1985	1330.0	
1932	6300.0		1986	1060.0	
1933	9340.0		1987	1320.0	
1934	3100.0		1988	1040.0	
1935	10200.0		1989	3610.0	
1936	6500.0		1990	5090.0	
1937	3380.0		1991	6760.0	
1938	3600.0		1992	4710.0	
1939	6450.0		1993	13000.0	
1940	5480.0		1994	2750.0	
1941	9600.0		1995	8930.0	
1965	4480.0		1996	932.0	
1966	6340.0		1997	3500.0	
1967	2340.0		1998	3840.0	
1968	15300.0		1999	4150.0	
1969	1800.0		2000	1440.0	
1970	5560.0		2001	1100.0	
1971	1780.0		2002	8270.0	
1972	1830.0		2003	6990.0	
1973	8200.0		2004	1860.0	
1974	2100.0		2005	3030.0	
1975	836.0		2006	28000.0	
1976	1120.0		2007	4330.0	
1977	2560.0		2008	4020.0	

1978	5100.0	2009	1530.0
1979	16200.0	2010	2180.0
1980	2460.0	2011	3390.0
1981	2460.0	2012	1560.0

Explanation of peak discharge qualification codes

PeakFQ CODE	NWIS CODE	DEFINITION
D	3	Dam failure, non-recurrent flow anomaly
G	8	Discharge greater than stated value
X	3+8	Both of the above
L	4	Discharge less than stated value
K	6 OR C	Known effect of regulation or urbanization
H	7	Historic peak

\- Minus-flagged discharge -- Not used in computation
-8888.0 -- No discharge value given
\- Minus-flagged water year -- Historic peak used in computation

1

Program PeakFq U. S. GEOLOGICAL SURVEY Seq.001.004
Ver. 5.2 Annual peak flow frequency analysis Run Date / Time
11/01/2007 following Bulletin 17-B Guidelines 05/08/2013 09:52

Station - 09473000 ARAVAIPA CREEK NEAR MAMMOTH, AZ.

EMPIRICAL FREQUENCY CURVES -- WEIBULL PLOTTING POSITIONS

WATER YEAR	RANKED DISCHARGE	SYSTEMATIC RECORD	BULL.17B ESTIMATE
1984	30000.0	0.0159	0.0159
2006	28000.0	0.0317	0.0317
1919	20000.0	0.0476	0.0476
1979	16200.0	0.0635	0.0635
1968	15300.0	0.0794	0.0794
1993	13000.0	0.0952	0.0952
1921	12600.0	0.1111	0.1111
1935	10200.0	0.1270	0.1270
1941	9600.0	0.1429	0.1429

1933	9340.0	0.1587	0.1587
1995	8930.0	0.1746	0.1746
2002	8270.0	0.1905	0.1905
1973	8200.0	0.2063	0.2063
1920	7400.0	0.2222	0.2222
2003	6990.0	0.2381	0.2381
1991	6760.0	0.2540	0.2540
1936	6500.0	0.2698	0.2698
1939	6450.0	0.2857	0.2857
1966	6340.0	0.3016	0.3016
1932	6300.0	0.3175	0.3175
1970	5560.0	0.3333	0.3333
1940	5480.0	0.3492	0.3492
1978	5100.0	0.3651	0.3651
1990	5090.0	0.3810	0.3810
1992	4710.0	0.3968	0.3968
1931	4700.0	0.4127	0.4127
1965	4480.0	0.4286	0.4286
2007	4330.0	0.4444	0.4444
1999	4150.0	0.4603	0.4603
2008	4020.0	0.4762	0.4762
1983	3920.0	0.4921	0.4921
1998	3840.0	0.5079	0.5079
1989	3610.0	0.5238	0.5238
1938	3600.0	0.5397	0.5397
1997	3500.0	0.5556	0.5556
2011	3390.0	0.5714	0.5714
1937	3380.0	0.5873	0.5873
1934	3100.0	0.6032	0.6032
2005	3030.0	0.6190	0.6190
1994	2750.0	0.6349	0.6349
1977	2560.0	0.6508	0.6508
1980	2460.0	0.6667	0.6667
1981	2460.0	0.6825	0.6825
1967	2340.0	0.6984	0.6984
2010	2180.0	0.7143	0.7143
1974	2100.0	0.7302	0.7302
2004	1860.0	0.7460	0.7460
1972	1830.0	0.7619	0.7619
1969	1800.0	0.7778	0.7778
1971	1780.0	0.7937	0.7937
1982	1620.0	0.8095	0.8095
2012	1560.0	0.8254	0.8254
2009	1530.0	0.8413	0.8413
2000	1440.0	0.8571	0.8571
1985	1330.0	0.8730	0.8730
1987	1320.0	0.8889	0.8889
1976	1120.0	0.9048	0.9048

2001	1100.0	0.9206	0.9206
1986	1060.0	0.9365	0.9365
1988	1040.0	0.9524	0.9524
1996	932.0	0.9683	0.9683
1975	836.0	0.9841	0.9841

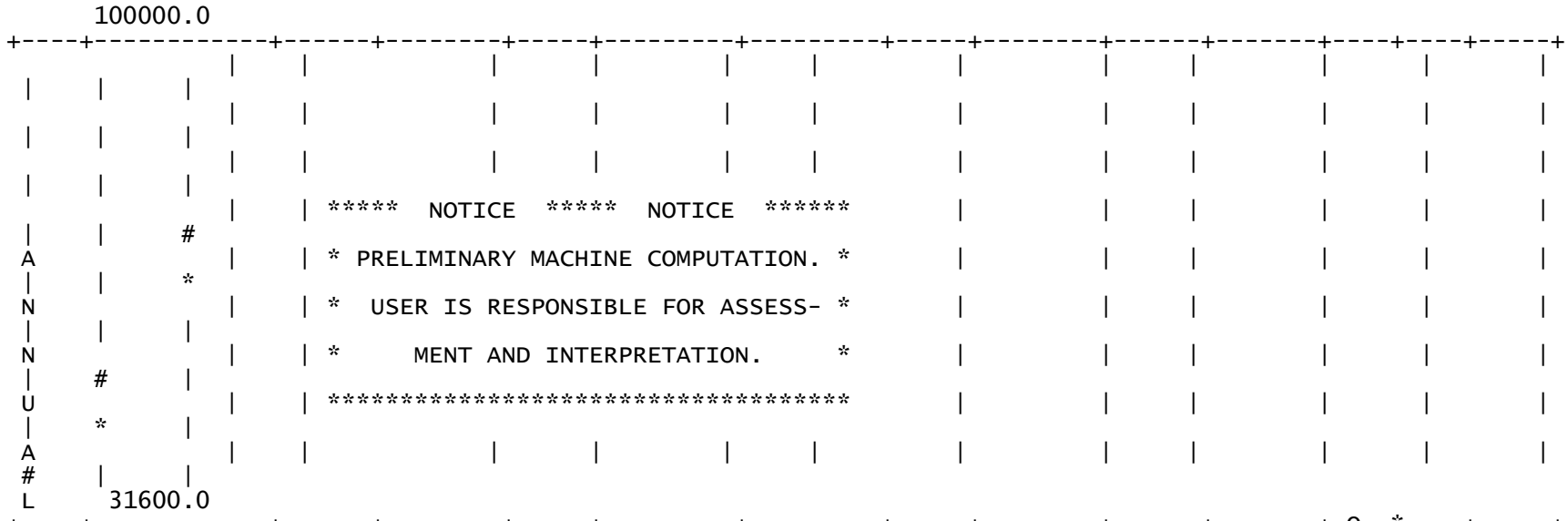
1

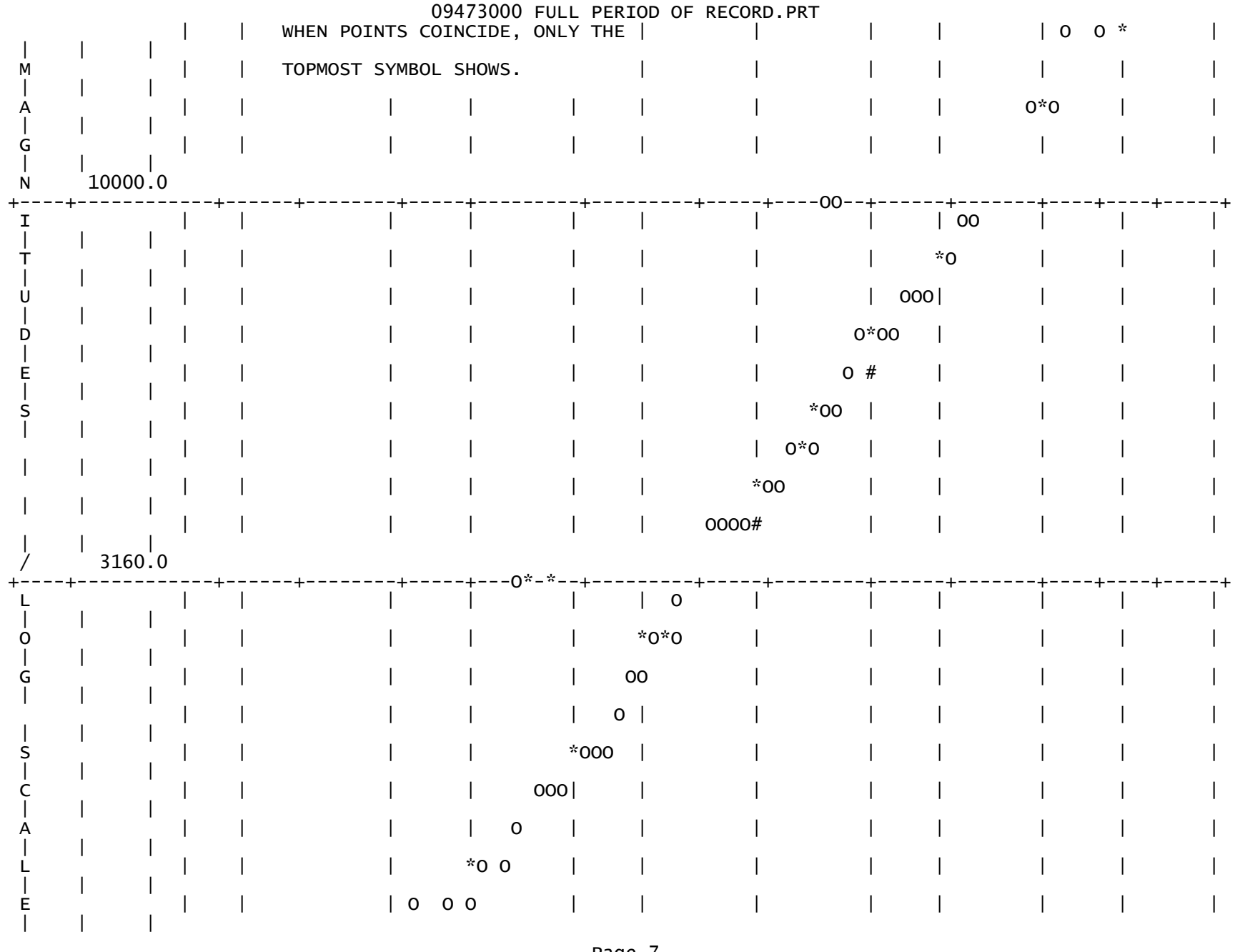
Program PeakFq
Ver. 5.2
11/01/2007

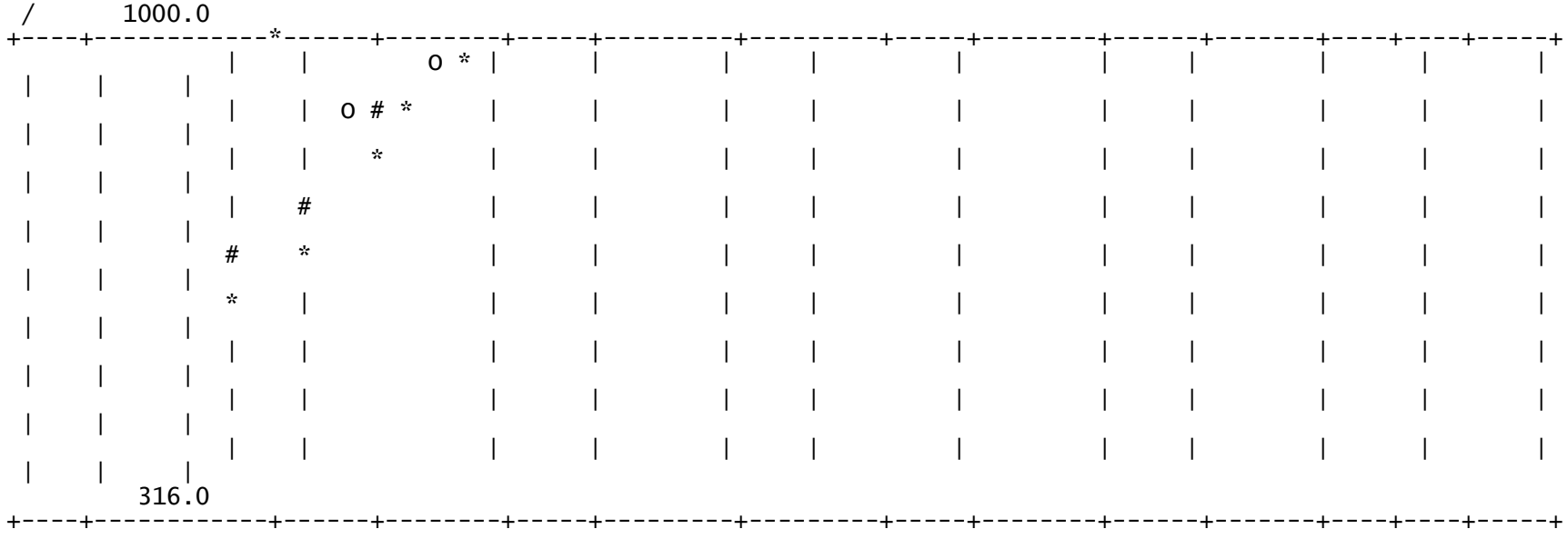
U. S. GEOLOGICAL SURVEY
Annual peak flow frequency analysis
following Bulletin 17-B Guidelines

Seq.001.005
Run Date / Time
05/08/2013 09:52

Station - 09473000 ARAVAIPA CREEK NEAR MAMMOTH, AZ.




WHEN POINTS COINCIDE, ONLY THE
TOPMOST SYMBOL SHOWS.
MAGNITUDE
10000.0
3160.0
LOG SCALE



1

End PeakFQ analysis.
Stations processed : 1
Number of errors : 0
Stations skipped : 0
Station years : 62

Data records may have been ignored for the stations listed below.
(Card type must be Y, Z, N, H, I, 2, 3, 4, or *.)
(2, 4, and * records are ignored.)

For the station below, the following records were ignored:

FINISHED PROCESSING STATION: 09473000 USGS ARAVAIPA CREEK NEAR MAMMOTH,

For the station below, the following records were ignored:

FINISHED PROCESSING STATION:

APPENDIX C

National Streamflow Statistics Program Output Reports

ACWA - East Boundary weighted
National Streamflow Statistics Program
Version 5
Based on Techniques and Methods Book 4-A6
Equations from database C:\NSS\NSS_v6_2012-11-21.mdb
Updated by tkoenig 11/21/2012 at 07:42:14 AM new low flow stats for VA

Site: unnamed, Arizona
User:
Date: Thursday, October 03, 2013 12:57 AM

Equations for Arizona developed using English units

Rural Estimate: Rural 1 (weighted)
   Basin Drainage Area: 542 square miles
   1 Region
   Region: Southern_Arizona_Region_13
      Drainage_Area = 542 square miles
   Crippen & Bue Region 16
     Weighted with 62 years of gaged data
      Interval PK2 Gaged value = 3816
      Interval PK5 Gaged value = 8005
      Interval PK10 Gaged value = 11950
      Interval PK25 Gaged value = 18490
      Interval PK50 Gaged value = 24660
      Interval PK100 Gaged value = 32060
      Interval PK500 Gaged value = 55150

Results for: Rural 1 (weighted)

Equations used:
PK2 = (+10)^(6.38)* (+10)^(-4.29*(DRNAREA)^(-0.06))
PK5 = (+10)^(5.78)* (+10)^(-3.31*(DRNAREA)^(-0.08))
PK10 = (+10)^(5.68)* (+10)^(-3.02*(DRNAREA)^(-0.09))
PK25 = (+10)^(5.64)* (+10)^(-2.78*(DRNAREA)^(-0.1))
PK50 = (+10)^(5.57)* (+10)^(-2.59*(DRNAREA)^(-0.11))
PK100 = (+10)^(5.52)* (+10)^(-2.42*(DRNAREA)^(-0.12))
PK500 = 0

Statistic	Value, cfs	Equivalent Years
PK2	3780	64
PK5	7800	68
PK10	11500	73
PK25	17600	77
PK50	23300	78
PK100	30200	78
PK500	55200*	

  *Extrapolated value
maximum: 728000 (for C&B region 16)

Rural Estimate: Rural 1
   Basin Drainage Area: 411 square miles
   1 Region
   Region: Southern_Arizona_Region_13
      Drainage_Area = 411 square miles
   Crippen & Bue Region 16

Results for: Rural 1

Equations used:
PK2 = (+10)^(6.38)* (+10)^(-4.29*(DRNAREA)^(-0.06))

ACWA - East Boundary weighted

PK5 = (+10)^(5.78)* (+10)^(-3.31*(DRNAREA)^(-0.08))
PK10 = (+10)^(5.68)* (+10)^(-3.02*(DRNAREA)^(-0.09))
PK25 = (+10)^(5.64)* (+10)^(-2.78*(DRNAREA)^(-0.1))
PK50 = (+10)^(5.57)* (+10)^(-2.59*(DRNAREA)^(-0.11))
PK100 = (+10)^(5.52)* (+10)^(-2.42*(DRNAREA)^(-0.12))
PK500 = 0

Statistic	Value, cfs	Standard Error, %	Equivalent Years
PK2	2460	57	2
PK5	5430	40	6.2
PK10	8380	37	11
PK25	13100	39	15
PK50	17100	43	16
PK100	22100	48	16
PK500	37000*		

*Extrapolated value
maximum: 637000 (for C&B region 16)

Rural Estimate: Rural 1 (weighted 2)
Basin Drainage Area: 411 square miles
1 Region
Region: Southern_Arizona_Region_13
Drainage_Area = 411 square miles
Crippen & Bue Region 16
Weighted as ungaged site
Gaged area = 542
Interval PK2 Gaged value = 3780
Interval PK5 Gaged value = 7800
Interval PK10 Gaged value = 11500
Interval PK25 Gaged value = 17600
Interval PK50 Gaged value = 23300
Interval PK100 Gaged value = 30200
Interval PK500 Gaged value = 55200

Results for: Rural 1 (weighted 2)

Equations used:
PK2 = (+10)^(6.38)* (+10)^(-4.29*(DRNAREA)^(-0.06))
PK5 = (+10)^(5.78)* (+10)^(-3.31*(DRNAREA)^(-0.08))
PK10 = (+10)^(5.68)* (+10)^(-3.02*(DRNAREA)^(-0.09))
PK25 = (+10)^(5.64)* (+10)^(-2.78*(DRNAREA)^(-0.1))
PK50 = (+10)^(5.57)* (+10)^(-2.59*(DRNAREA)^(-0.11))
PK100 = (+10)^(5.52)* (+10)^(-2.42*(DRNAREA)^(-0.12))
PK500 = 0

Statistic	Value, cfs	
PK2	2890	30
PK5	6130	34
PK10	9220	38
PK25	14200	42
PK50	18800	43
PK100	24300	43
PK500	42700*	

*Extrapolated value
maximum: 637000 (for C&B region 16)

National Streamflow Statistics Program
Version 5
Based on Techniques and Methods Book 4-A6
Equations from database C:\NSS\NSS_v6_2012-11-21.mdb
Updated by tkoenig 11/21/2012 at 07:42:14 AM new low flow stats for VA

Site: unnamed, Arizona
User:
Date: Thursday, October 03, 2013 01:03 AM

Equations for Arizona developed using English units

Rural Estimate: Rural 1 (weighted)
   Basin Drainage Area: 542 square miles
   1 Region
   Region: Southern_Arizona_Region_13
      Drainage_Area = 542 square miles
   Crippen & Bue Region 16
     Weighted with 62 years of gaged data
      Interval PK2 Gaged value = 3816
      Interval PK5 Gaged value = 8005
      Interval PK10 Gaged value = 11950
      Interval PK25 Gaged value = 18490
      Interval PK50 Gaged value = 24660
      Interval PK100 Gaged value = 32060
      Interval PK500 Gaged value = 55150

Results for: Rural 1 (weighted)

Equations used:
PK2 = (+10)^(6.38)* (+10)^(-4.29*(DRNAREA)^(-0.06))
PK5 = (+10)^(5.78)* (+10)^(-3.31*(DRNAREA)^(-0.08))
PK10 = (+10)^(5.68)* (+10)^(-3.02*(DRNAREA)^(-0.09))
PK25 = (+10)^(5.64)* (+10)^(-2.78*(DRNAREA)^(-0.1))
PK50 = (+10)^(5.57)* (+10)^(-2.59*(DRNAREA)^(-0.11))
PK100 = (+10)^(5.52)* (+10)^(-2.42*(DRNAREA)^(-0.12))
PK500 = 0

Statistic	Value, cfs	Equivalent Years
PK2	3780	64
PK5	7800	68
PK10	11500	73
PK25	17600	77
PK50	23300	78
PK100	30200	78
PK500	55200*	

  *Extrapolated value
maximum: 728000 (for C&B region 16)

Rural Estimate: Rural 1
   Basin Drainage Area: 503 square miles
   1 Region
   Region: Southern_Arizona_Region_13
      Drainage_Area = 503 square miles
   Crippen & Bue Region 16

Results for: Rural 1

Equations used:
PK2 = (+10)^(6.38)* (+10)^(-4.29*(DRNAREA)^(-0.06))

ACWA - West Boundary weighted

PK5 = (+10)^(5.78)* (+10)^(-3.31*(DRNAREA)^(-0.08))
PK10 = (+10)^(5.68)* (+10)^(-3.02*(DRNAREA)^(-0.09))
PK25 = (+10)^(5.64)* (+10)^(-2.78*(DRNAREA)^(-0.1))
PK50 = (+10)^(5.57)* (+10)^(-2.59*(DRNAREA)^(-0.11))
PK100 = (+10)^(5.52)* (+10)^(-2.42*(DRNAREA)^(-0.12))
PK500 = 0

Statistic	Value, cfs	Standard Error, %	Equivalent Years
PK2	2670	57	2
PK5	5860	40	6.2
PK10	9010	37	11
PK25	14000	39	15
PK50	18300	43	16
PK100	23600	48	16
PK500	39300*		

*Extrapolated value
maximum: 702000 (for C&B region 16)

Rural Estimate: Rural 1 (weighted 2)
Basin Drainage Area: 503 square miles
1 Region
Region: Southern_Arizona_Region_13
Drainage_Area = 503 square miles
Crippen & Bue Region 16
Weighted as ungaged site
Gaged area = 542
Interval PK2 Gaged value = 3780
Interval PK5 Gaged value = 7800
Interval PK10 Gaged value = 11500
Interval PK25 Gaged value = 17600
Interval PK50 Gaged value = 23300
Interval PK100 Gaged value = 30200
Interval PK500 Gaged value = 55200

Results for: Rural 1 (weighted 2)

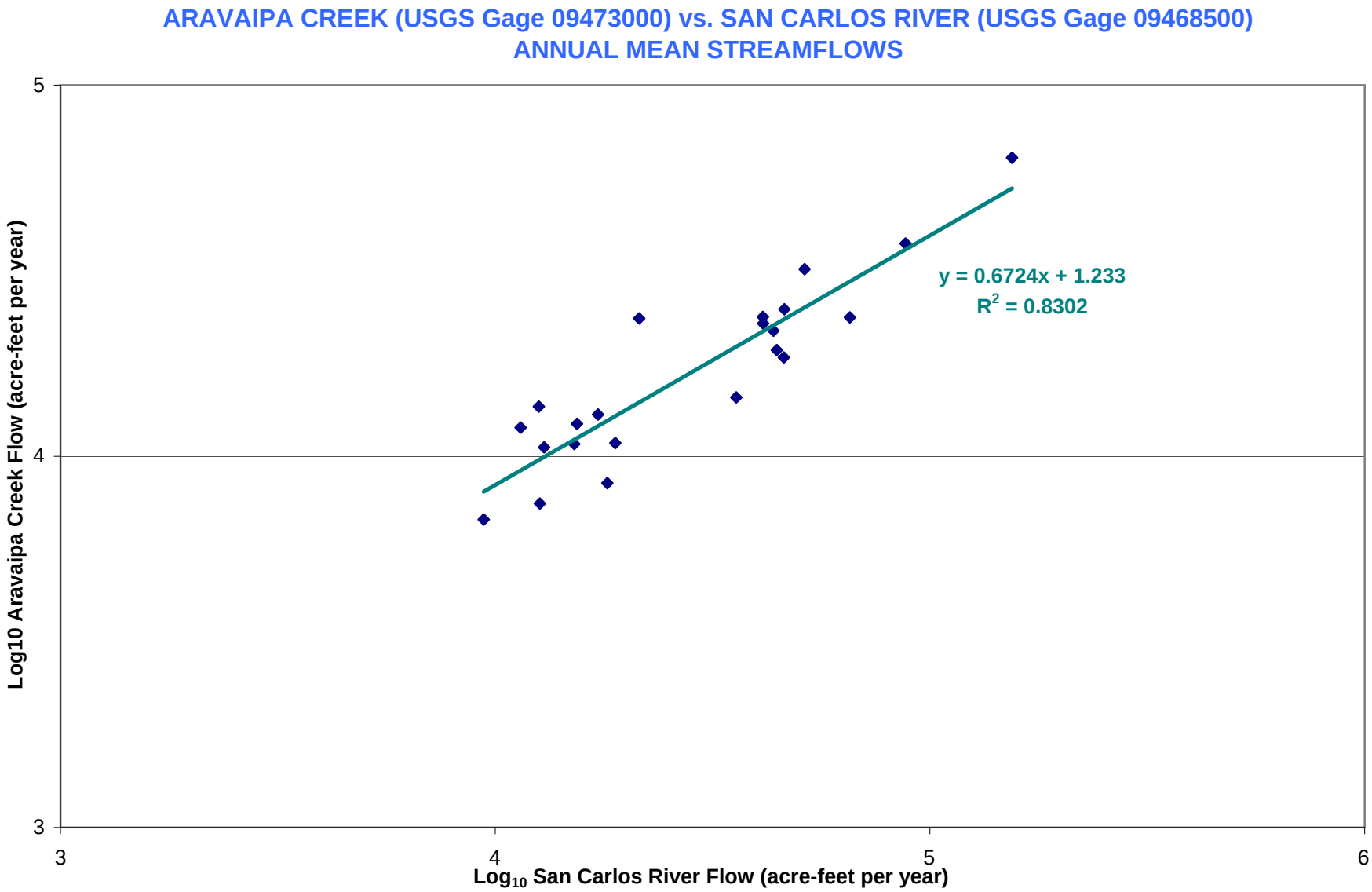
Equations used:
PK2 = (+10)^(6.38)* (+10)^(-4.29*(DRNAREA)^(-0.06))
PK5 = (+10)^(5.78)* (+10)^(-3.31*(DRNAREA)^(-0.08))
PK10 = (+10)^(5.68)* (+10)^(-3.02*(DRNAREA)^(-0.09))
PK25 = (+10)^(5.64)* (+10)^(-2.78*(DRNAREA)^(-0.1))
PK50 = (+10)^(5.57)* (+10)^(-2.59*(DRNAREA)^(-0.11))
PK100 = (+10)^(5.52)* (+10)^(-2.42*(DRNAREA)^(-0.12))
PK500 = 0

Statistic	Value, cfs	
PK2	3500	53
PK5	7280	57
PK10	10800	62
PK25	16500	66
PK50	21900	67
PK100	28300	67
PK500	51200*	

*Extrapolated value
maximum: 702000 (for C&B region 16)

APPENDIX D

Aravaipa Creek vs. San Carlos River Annual Mean Streamflow Regression


ARAVAIPA CREEK (USGS Gage 09473000) vs. SAN CARLOS RIVER (USGS Gage 09468500)
ANNUAL MEAN STREAMFLOWS
y = 0.6724x + 1.233
R2 = 0.8302
Log10 Aravaipa Creek Flow (acre-feet per year)
Log10 San Carlos River Flow (acre-feet per year)
5
4
3
3
4
5
6

SUMMARY OUTPUT

Regression Statistics	
Multiple R	0.91114598
R Square	0.830187
Adjusted R Square	0.82169635
Standard Error	0.10154264
Observations	22

The standard error of estimate is in log base 10 units and equivalent to -21% to +26%. This indicates that, for a given year, the actual annual flow in Aravaipa Creek would typically be from 21% lower to 26% higher than the estimated value. Based on how the regression was performed, there will be some years when the estimates are high and other years when the estimates are low which balance each other out over the period of missing record. See the residual plot included in this appendix.

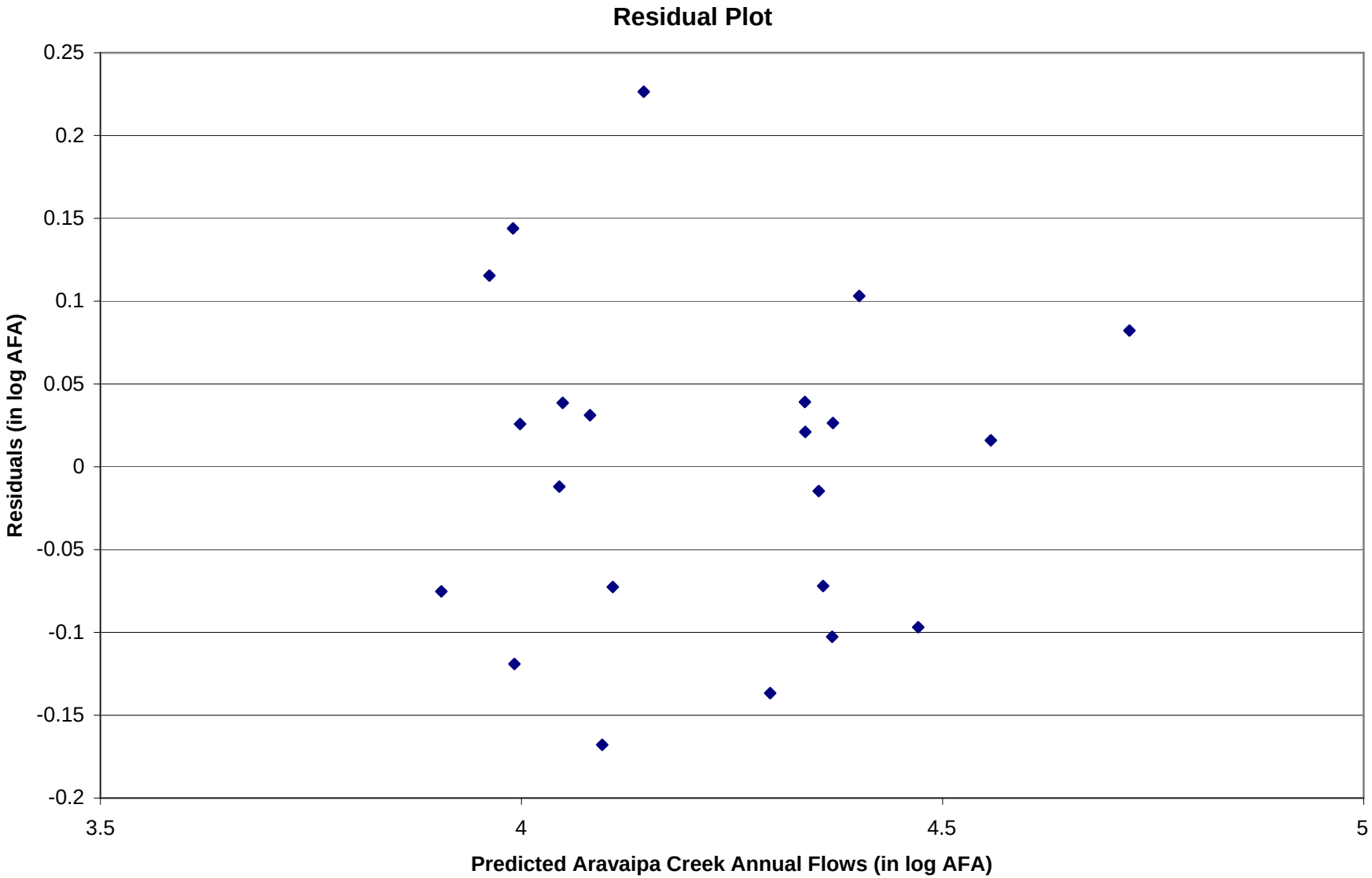
ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	1	1.008165674	1.008166	97.77661	3.82088E-09
Residual	20	0.206218166	0.010311		
Total	21	1.214383839			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*
Intercept	1.23303142	0.303310761	4.065241	0.000604	0.600336261	1.86572658
X Variable 1	0.67237791	0.06799797	9.888206	3.82E-09	0.530536634	0.81421919

RESIDUAL OUTPUT

Observation	*Predicted Y*	*Residuals*
1	4.33696649	0.021062839
2	4.08142311	0.031148696
3	3.99823387	0.025837756
4	4.55722578	0.015983537
5	4.35816808	-0.071938051
6	4.36890667	-0.10264772
7	4.04901627	0.038589205
8	4.10836095	-0.072550923
9	4.40099938	0.103157978
10	4.14510721	0.226494917
11	4.33645464	0.039137978
12	4.3528892	-0.014603938
13	4.04487421	-0.011969175
14	3.98996108	0.143915541
15	4.29525827	-0.136686425
16	4.36982206	0.026455149
17	4.47112761	-0.096861089
18	3.96179371	0.115409
19	4.09578715	-0.167882518
20	3.90483407	-0.075233656
21	3.99163449	-0.119078498
22	4.72194205	0.082259397


Residual Plot
0.25
0.2
0.15
0.1
0.05
0
-0.05
-0.1
-0.15
-0.2
Residuals (in log AFA)
3.5
4
4.5
5
Predicted Aravaipa Creek Annual Flows (in log AFA)